HARMSWORTH POPULAR SCIENCE

EDITED BY ARTHUR MEE

ARISTOTLE DISCUSSING LIFE WITH PLATO

FROM THE FRESCOES OF THE VATICAN, BY RAPHAEL, SHOWING PLATO POINTING UP TO HEAVEN, AND ARISTOTLE POINTING TO THE EARTH

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POPULAR SCIENCE

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Supplementary Volume of

SCIENCE BIOGRAPHIES

Embracing 500 Lives of

BIOLOGISTS—The Explorers of the Mystery of Life
EXPLORERS—Seekers and Finders of New Lands
THINKERS—The Founders of Scientific Thought
INVENTORS—Transformers of Knowledge into Power
PIONEERS—Forerunners of Knowledge and Progress
CHEMISTS—The Searchers of Matter
PHYSICISTS—The Searchers of Energy
ASTRONOMERS—Discoverers of the Universe
GEOLOGISTS—Historians of the Prehistoric World

With Bibliography of 1000 Scientific Books

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VOLUME SEVEN

AMALGAMATED PRESS, LONDON, E.C.

1913

BIOGRAPHIES IN THIS VOLUME

GROUP 1. BIOLOGISTS
Explorers of the Mystery of Life

GROUP 2. EXPLORERS
Seekers and Finders of New Lands

GROUP 3. THINKERS
Founders of Scientific Thought

GROUP 4. INVENTORS
Transformers of Knowledge into Power

GROUP 5. PIONEERS
Forerunners of Knowledge and Progress

GROUP 6. CHEMISTS AND PHYSICIANS

Searchers of Matter and Energy

GROUP 7. ASTRONOMERS

Discoverers of the Universe

GROUP 8. GEOLOGISTS

Historians of the Prehistoric World

THE LAST VOLUME OF "POPULAR SCIENCE"

THE MEN OF FOREVER

THE time has come when we are in sight of the end of these pages. With these words POPULAR SCIENCE opens its final volume.

It has sought to fill a vacant place on the bookshelves of our time. There have been books of popular science before, but no other book can quite compare with this. It has sought no reflected glory from great names, but it has within it an authority that mere names in themselves can never give. It would have been easy to fill the front page of this work with illustrious names that carry weight and give distinction; it would have been simple to adopt the conventional way of advertising the authority of a scientific work. But it would not have been easy, in such a case, to give to POPULAR SCIENCE that comprehensiveness, that plainness of language, that picturesqueness of treatment, that freedom of method, that abundance of illustration, which have been characteristic of it from the beginning.

It is hoped that POPULAR SCIENCE is its own vindication, that the wisdom of its method has abundantly declared itself as these pages have made their meaning plain. These volumes were designed to be a great Court of Appeal for those who, knowing little of scientific things, might seek enlightenment in any one of a hundred fields in which men nowadays engage their thoughts. We are all scientists now, in some degree; we live in an age when the clock can barely go round once without marking the birth of some new idea, some great discovery, some far-reaching invention.

And so it is hoped that this work has responded to a real demand, in providing a popular statement of the scientific outlook on the world, a popular record of the scientific achievements of our own age and ages past, and a scientific vision of the future to which both past and present lead, and of which we are largely the makers. We have sought to remember in all things that science, which is truth, knows neither place nor time; we have sought to keep out of these pages whatever serves a smaller thing than Truth itself; we have sought to embrace within these volumes as complete a scheme of scientific knowledge as could be brought together in a single work. It is a book of information, a book of ideas, a book of hope and faith as well; and it holds no narrow view of Life. No man can be a poorer citizen, and he may well be a richer, for anything he has read in these pages now advancing to their end.

No word of apology is needed for the shape this final volume takes. If science knows no ending, it is because the men of science go on for ever learning, for ever probing deeper into the mysteries of Life, for ever creating new instruments of knowledge and new forces for progress.

Who are these men who thus hold in their hands the keys of Nature that are opening wide, and will open wider still, the doors of the Temple? This volume will introduce us to them. Who were they who laid for us the foundation of learning, in toil and often in tribulation, during ages past? These pages will introduce us to them also; the thinkers, inventors, and discoverers; the explorers of the earth and of the universe. Men of yesterday, today, and of the great For Ever, come into our human story. Past, Present, and Future are here.

So that we end, in this volume, with our eyes on the horizon. Wider and wider Nature throws open her doorways, wider and wider the river of knowledge flows. Farther through the telescope, deeper through the microscope, the eyes of men peer into the depths. What will they see in the days that lie beyond us? We who, as these words are written, flash our thoughts across the sea, and await the day when we shall bridge the ocean with our very voices—how shall we speak, and where, and by what wondrous power, when the men now working out the mysteries of the ether have taken their next leap into the future? We who toil and spin with mighty instruments of power like steel cathedrals—how shall we use our leisure when the explorer of the atom chains this invisible force to do our toiling for us?

That great day waits, and we can only dimly see. But the sun will rise, and men's eyes will see the dawn.

ARTHUR MEE

THREE EARLY STUDENTS OF BIOLOGY

MARIE FRANÇOIS BICHAT

SIR JOSEPH BANKS

SIR CHARLES BELL

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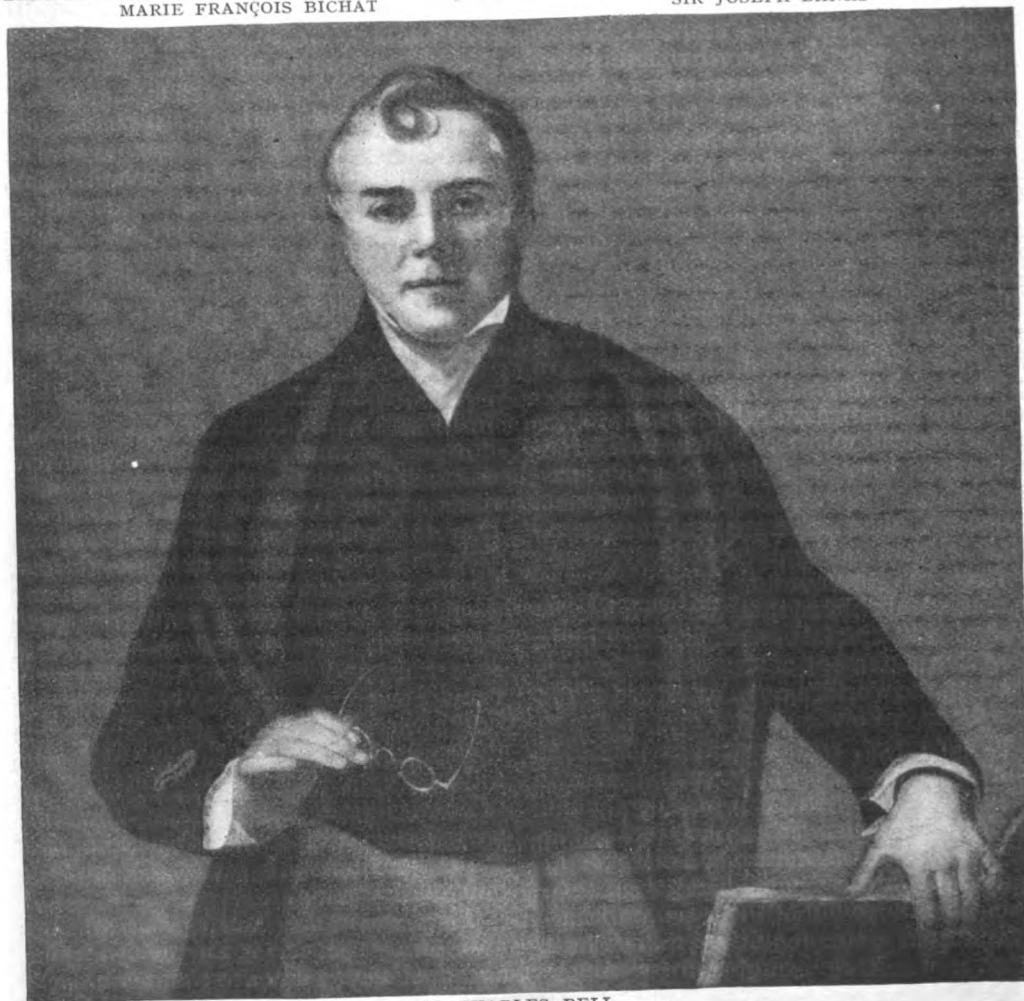

BIOLOGISTS

JEAN LOUIS AGASSIZ

"A Great International"

JEAN LOUIS RODOLPHE AGASSIZ, one of the most popular men of science of the second and third quarters of the nineteenth century, and almost the last to remain faithful to the theory of special creation against the proofs of evolution, was the son of a Swiss pastor in the Fribourg Canton. He was born at Motier, in the neighbourhood of Lake Neuchâtel, on May 28, 1807. His education, begun in Switzerland, was continued in Germany and France, and he graduated both in philosophy and medicine.

While still a student, his attention was drawn to the study of fishes by a request that he would arrange a collection of fresh-water fishes that had been brought to Switzerland from Brazil, and he passed on from this work to a study of the fishes of his native district. When only four-and-twenty he was appointed Professor of Natural History in the University of Neuchâtel. It was a natural transition from the study of living fishes to the study of the fossils of the species, as they abound in Switzerland. Extended studies led Agassiz to introduce a new classification, which, however, has not entirely held the field. From fishes he enlarged the range of his observations to invertebrate animals, and quickly attained a European reputation.

Coming to England, he made the acquaintance of Hugh Miller, and by his appreciation of the studies of the Scottish stonemason—which lay largely in the fish-bearing strata—helped to popularise that unfortunate genius. On his return to Switzerland, Agassiz took up the study of glacial movement, so closely associated later with the names of Forbes and Tyndall, and his theories of glacial action attracted universal attention. During a later visit to England he, working with Buckland, described, according to his theory, the effects of glaciation in this country.

He was now invited to lecture in the United States, and arrangements were made for a study by him of the geology of the Republic, which, till that time, had been quite inadequately undertaken. His work in America, prodigious in amount, and covering a very wide range, was so much appreciated that, though he suffered terribly from home-sickness, he never returned to Switzerland.

He was appointed Professor of Zoology and Geology at Harvard, and joined the circle of delightful men who in that day gave the United States a distinction in the world of literature which it has never attained since. One of his innumerable activities was the formation at Cambridge of a scientific museum. This he finally gave to the public. Even the holidays which so rarely diversified his strenuous work were spent as scientific excursions, and carried him as far afield as Brazil. His studies in the Alps had convinced him of the need for a study of Nature where the objects under observation were *in situ*, and so he established on an island a practical school of marine zoology.

The work of Agassiz had the double character of popular exposition and original research, and in its enthusiastic prosecution he wore himself out. He died at Cambridge on December 14, 1873, and his grave is marked by a glacial boulder and pine-trees sent out from his native Switzerland.

The impression made by the personality of this charming man of science is reflected with fine truth and delicacy in the poem read by Longfellow at the meeting commemorating the Switzer's fiftieth birthday.

Though some of the views held by Agassiz have been overthrown, and his work was too wide and eager to be always exact, he holds an honourable place as a devotee of science. He left a son, Alexander, who carried his work on with distinction, and a wife who proved a sympathetic biographer.

LORD AVEBURY

A Student and Friend of Insects

Lord Avebury, known until his elevation to the Peerage, in 1900, as Sir John Lubbock, was born on April 30, 1834, in London. His father was a banker, who was also, however, a scientific amateur, belonging to the distinguished class of such who have played a large part in the development of science in this country. The young Lubbock became a banker, like his father, but he also inherited strong and effective scientific tastes.

As a politician Lord Avebury was responsible for the introduction of Bank Holidays in 1871, and for the Shop Hours Act of 1889. In 1881 he was President of the British Association. Throughout his life he has been a copious writer on many subjects. His books on the influence of geology on scenery, illustrated specially in the scenery of the British Islands, and of Switzerland, have added scientific interest to the pleasures of travel.

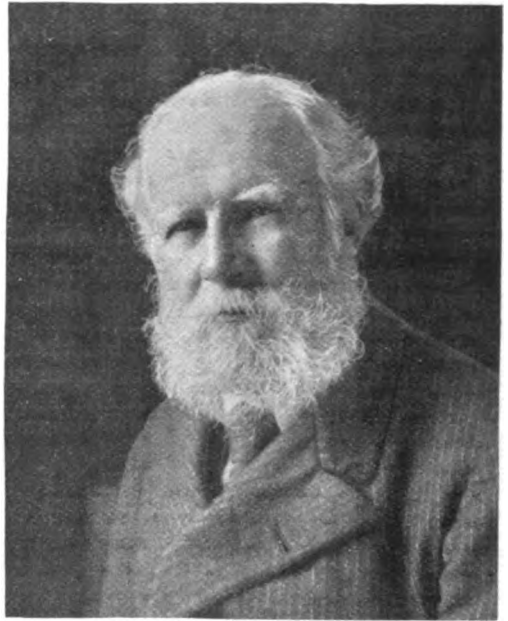
His popular chatty volumes on "The Use of Life" and "The Pleasures of Life" were widely read, and he was an early student of early man and primitive society.

His first-hand work upon very different kinds of societies is, however, his most notable claim to the respect of students of science. Already in 1874 we find him contributing to the study of insects, and his "Ants, Bees, and Wasps," published in 1882, must long be a classic on this subject. To Lord Avebury is due the real and substantial credit of having been able to recognise the interest of insect societies before it was generally perceived. His work, thought at first to be of a kind almost beneath the dignity of professional naturalists, has proved to be the starting point of a branch of study still only in its infancy, and from which some of the most significant truths of the living world are being obtained. In many notable respects insect societies, and the instinctive capacities of insects, as studied by Lord Avebury with such success a generation ago, are superior to anything in human achievement. The philosophical significance of these facts has been appreciated by Bergson in his "Creative Evolution," and in Maeterlinck's "Life of the Bee."

Entomology has proceeded in many new directions during the last three decades, notably in its economic relations, and in regard to the influence of insect lite upon the incidence and conveyance of disease in the higher animals and ourselves. But entomology is to be valued above all for its contributions to the philosophical and central problems of biology and of psychology, and the name of Lord Avebury will always rank among its pioneers.

J. W. BALLANTYNE

Science as the Friend of Motherhood

Dr. J. W. Ballantyne was born at Dalkeith, near Edinburgh, in June, 1861. He entered the University of Edinburgh in 1877, and early began to devote himself to the subject which he has made his own, the study and the care of ante-natal life. He has always been a hard worker, with a guiding idea in view. In 1883, at graduation, we find him already started on that inquiry which, thirty years later, is recognised under

LORD AVEBURY
Photograph by R. Haines

the "maternity benefit" of 1913, with its reference to, at any rate, the last fortnight of ante-natal life.

As in many other instances, the study of disease and the abnormal has led on to something better still. Dr. Ballantyne is the recognised founder of ante-natal pathology, a subject on which he has published two large volumes and a host of papers. But his observations on disease, deformity, and upon such monstrosities as the public makes acquaintance with under such names as the "Siamese Twins," may be regarded, as preliminary to that constructive demand for expectant motherhood which has found voice and practical

form in Dr. Ballantyne's work during the present century.

Ante-natal disease is often liable to lead to a tragedy, single or double, when the crisis of birth arrives. These are the most awful events in medical practice, the best skill and attention being often powerless before them. Every maternity hospital is familiar with them, the patient arriving *in extremis* when the case has been found hopeless outside. Dr. Ballantyne's first task, therefore, was to systematise and extend our knowledge of ante-natal disease.

For this the maternity hospitals have made no provision, but in 1901, thanks to Dr. Ballantyne's advocacy and to the generosity of one of the physicians to the Edinburgh Maternity Hospital, a bed was endowed and opened for the purpose. That bed has now become a pro-maternity ward, the first-fruits of one of the greatest ideas in the history of medical science.

More than ten years ago, an American critic of Dr. Ballantyne's work wrote that "ante-natal pathology is preventive medicine in its most hopeful aspect, yet it is practically unexplored." But Dr. Ballantyne has proceeded to the study of all those dietetic, toxic, and other conditions of expectant motherhood which may be of importance, first because they may kill or nearly kill the mother when the crisis of birth arrives, and second because they affect the earliest nurture of her child.

In this connection Dr. Ballantyne has directed special attention to such agents as alcohol, lead, and the toxic products of certain infections, such as syphilis. Directly the study of infant mortality and the general physiology of infant life began to assume its real importance in this country, it became apparent that Dr. Ballantyne had not spent all these years upon a subject unfit for more than the gratification of an almost morbid curiosity. On the contrary, he was investigating causes of which all men are in large measure the consequences.

It soon became clear to Dr. Ballantyne that the organ called the placenta, which is distinctive to the higher members of the Mammalian, or highest order of animals, is all-important in ante-natal life. It is entirely unique in the world of life, for it is a double organ, half of it being derived from maternal tissue, and half of it from the child; in it, therefore, two generations are one. By means of it the new generation is nurtured, ventilated, cleansed. The unborn child finds in the placenta not merely mouth and stomach, but lungs and kidneys and skin.

Nay, more. Dr. Ballantyne found, when all the existing data were collated and digested, that the placenta is a protective filter, which keeps back from the child many agents that may be circulating within the blood of the mother, and may be poisoning, and indeed killing, her. Against certain substances, however, to which we have already referred, the placenta is almost or wholly powerless. The identification of those substances would alone entitle any man to lasting fame.

If we are to have more useful power, we must have more knowledge, and that knowledge is now being slowly but surely obtained by Dr. Ballantyne and his followers. In a remarkable and prophetic paper, contributed to medical literature in 1901, Dr. Ballantyne described that which then existed only in his mind, and now exists only in so far as a single ward in the Edinburgh Maternity Hospital is concerned, but may be more nearly realised before the life-work of this veritable pioneer, now in his prime, is completed.

In the Pro-Maternity Hospital of Dr. Ballantyne's dream, there was a Salle des Innocents, where expectant mothers were being treated with mercury, though they were free from syphilis themselves, because the fathers of their children had had the disease, and now, or never, was the time to cure the unborn and innocent victims. In another ward the expectant mothers were being so wisely nourished that the nutrition of their unborn children was being promoted in order to avert the misfortune of premature birth, which is at this moment the cause of one-fourth of our infant mortality. Above the portal of another ward was the word "Heredity," and therein the visitor saw a member of a hæmophilic family, now on her way towards confinement, with its terrible risk for herself and her unborn infant. Then, he says, "I had a peep into the ward of the habitual inebriates, who were being kept from all alcoholic preparations during pregnancy."

Such was the dream of this dreamer, who belongs to the rare and illustrious band of those natural leaders of mankind who, dreaming, work until their dreams come true—which is Parturition indeed.

SIR JOSEPH BANKS

A Nature-Traveller Round the World

Sir Joseph Banks, the famous botanist, was born in London on February 13, 1743. He was educated at Harrow, Eton, and Oxford, but nevertheless retained the keen

taste for the study of natural objects which was inborn in him. He was a man of considerable wealth, which he devoted to the great interest of his life, and in him we thus find a notable member of that band of amateurs who are almost the peculiar glory of English science.

His first voyage was made to Newfoundland, when he was only twenty-three. Two years later he accompanied Captain Cook on his voyage round the world, in a ship provided by himself. With him on this voyage was a pupil of the great Linnæus, and from the first it could be seen that Banks meant his collections to be systematic and exhaustive, after a fashion that would have pleased the father of systematic nomenclature himself.

Banks was the first man to describe Staffa, the geological wonder of Scotland, and at the early age of thirty-five he became President of the Royal Society, a post which he retained until his death, more than forty years later. He accepted a baronetcy in 1781. The bread-fruit and the mango were introduced into the West Indies by him. He died at Isleworth, on June 19, 1820, bequeathing his books and botanical collection to the British Museum.

SIR THOMAS BARLOW

A Master-Student of Infant Life

Sir Thomas Barlow was born at Edgworth, in Lancashire, on September 4, 1845. He was educated at Owens College, Manchester, and University College, London, and, while studying various departments of general medicine, devoted himself particularly to the diseases of childhood. He is consulting physician to the Hospital for Sick Children in Great Ormond Street.

In 1895 Sir Thomas Barlow described the characteristics of a malady of infancy which is generally known as "infantile scurvy," or "Barlow's disease." This is due to errors of nutrition, and the recognition and study of it have thrown much light upon the subtler and more important aspects of human diet in the earlier stages of development. Among other notable results of such studies, Sir Thomas Barlow has been led to take up a position worthy of his record in regard to the abuse of alcohol in medical practice.

He received the honours of knighthood and a baronetcy in 1901. In 1909 he became a Fellow of the Royal Society, and since 1910 has been the President of the Royal College of Physicians. In the autumn of 1912 he accepted the office of chairman of the National Association for the Welfare of Infancy, which was then formed, and since that date he has worked steadily for this body, and thus for the practical realisation of the scientific inquiries to which his life has been devoted.

HENRY WALTER BATES

Taking Science into the Forests

Henry Walter Bates, one of the last of the old school of "naturalists," was born at Leicester on December 8, 1825. The son of a hosier in that city, he was predestined to botanise, collect, and explore. Before he was twenty, he met Mr. Alfred Russel Wallace, who was only a couple of years older, and in 1848 the two set sail for South America. There they worked together for two years, and for nine years more Bates continued his travels and observations, succeeding, as Mr. Edward Clodd tells us, in collecting eight thousand species of insects formerly undescribed.

On his return to England he was appointed, in 1864, assistant-secretary to the Royal Geographical Society, and in that post he did useful work of another kind for science. In the preceding year Bates had published his "Naturalist on the River Amazon," persuaded thereto by Darwin himself.

The pioneer work of Bates as a describer and collector of new living forms will always stand to his credit, though such work, like much which was more necessary in the past than today, is purely of a mechanical and routine order. Interpretation, the ultimate aim of science, is the essential matter; and on this plane the name of Bates will always be associated with his interpretation, based on his observations on the Amazon, of the resemblances which are sometimes found between individuals of species far removed in the kingdom of life—even between leaves and insects, and also between living organisms and the colour or texture of their usual environment. The theory of Bates was a strictly Darwinian one, the argument being that the peculiar characters of the species which mimicked another, or its surroundings, were favoured and produced by "natural selection." It is now, however, necessary to reconsider all these questions in the light of our slowly accumulating and still inadequate knowledge of the origin of variations.

Bates made a great collection of certain species of insects during his latter years. He was elected a Fellow of the Royal Society, and died on February 16, 1892.

WILLIAM BATESON

The English Leader in the Study of Heredity

William Bateson was born at Whitby in 1861, son of the Rev. W. H. Bateson, Master of St. John's College, Cambridge. He was educated at Rugby and Cambridge, and proceeded to research in biology.

His first book, "Materials for the Study of Variation," was published in 1894, and its title sufficiently suggests what was to follow. Already, in his early thirties, the young student was wholly dissatisfied with what had by that time become the orthodox creed of biology regarding the nature and origin of variations. Though this subject

HENRY BATES AMONG THE TOUCANS
The Frontispiece to "The Naturalist on the River Amazon"

lies at the very foundation of organic evolution, so that no superstructure can be built upon any other, the fact remains that Darwin and his followers had devoted extremely little attention to the primary questions which it involves. The materials for any adequate study of the subject had not even been collected.

At that date the name of Mendel was unknown to the young sceptic who was not satisfied with orthodox Darwinism, as well as to everyone else, though the Silesian student had been dead for ten years, and though his essential work was actually already thirty years old. Six more years of continued research were to pass before, in 1900, attention was directed to Mendel's work. This was precisely the starting point for which Bateson had been seeking, without any idea that it had already been reached by a predecessor.

The constructive work of Professor Bateson thus dates from the beginning of the present century, during which he has become, very definitely, the leader of the new school in biology. The discovery of Mendel's work became a searching test of the real quality of biological students. The great majority, as was to be expected, failed to see its significance, and were content with the Darwinian explanation of organic evolution, in which all the elder among them had been brought up. But Professor Bateson, as his previous work had shown, was ready for the new illumination and prepared to go whither it led.

As early as 1902 he published a small book, called "Mendel's Principles of Heredity," in which he showed what Mendel's discovery must mean for biology, at a time when it was thought to be, at most, a mere freak of Nature, under unusual and unimportant conditions. That small book became the nucleus of the large volume published under the same title in 1909, and now the standard work upon Heredity. A third edition, revised and brought up to date, was published early in 1913.

In 1904 Professor Bateson was awarded the Darwin medal of the Royal Society; in 1907 he gave the Silliman Lectures at Yale University; in 1908-9 he held the new Chair of Biology at Cambridge, founded in honour of Darwin; and he is now Professor of Physiology at the Royal Institution, and has been director of the John Innes Horticultural Institution, Merton, Surrey, since 1910. There he continues his researches upon the laws of heredity by the method of experimental breeding which Mendel employed, and which had been almost wholly neglected by biologists since the publication of the "Origin of Species."

To Professor Bateson we owe the introduction of the much-needed word "genetics," by which is meant the physiology or natural laws of heredity and variation. Though the word is scarcely yet familiar, even to many professed biologists, a Chair bearing this title already exists at Cambridge, and is occupied by Professor Bateson's principal follower in this country.

The more essential features of Professor Bateson's contributions to biology are best

to be found in the inaugural lecture which he delivered on his appointment to the now defunct Chair of Biology at Cambridge in 1908, and which is entitled "The Methods and Scope of Genetics."

Genetics, according to its great pioneer of today, is in the main line of progress; it "is still pushing forward in the central undifferentiated trunk of biological science. . . . Mendel's clue has shown the way into a realm of Nature which for surprising novelty and adventure is hardly to be excelled." Those who are well acquainted with Professor Bateson as a living figure of our time will be aware of the zest and sense of splendid discovery with which his work is done and its results declared. A leader like this finds followers.

Mendel had shown that certain opposite characters of living things are relatively "dominant" or "recessive" in inheritance. If parents having these characters respectively be mated there is no compromise or blending, but the "dominant" character appears in all the offspring. Mendel offered no explanation of dominance and recessiveness as he had discovered them. To have attempted and achieved the explanation is Professor Bateson's chief contribution to genetic theory, as distinguished from the accumulation of data by research. He has formulated what used to be called the "presence and absence hypothesis," but what is now more than a speculation, and is indeed clearly the explanation of the facts. In brief, dominance in heredity is due to the presence in a germ-cell of a factor, the absence of which from that germ-cell would lead to the appearance of the recessive character. We are no longer required to believe in the existence of puzzlingly opposite factors in the germ-cells, but in the presence or absence of a factor, in the presence of which the dominant character will appear, while the recessive character will appear in its absence.

It is natural to ask what are the "factors" in the germ-cells whose presence and absence have such large and definite consequences. For this question genetics has been fortunate, in that its leader has the philosophic breadth of mind to see where his particular department of science comes into relation with, and requires the assistance of, others. Professor Bateson points out that physiological chemistry stands in the closest possible relation to the ultimate problems of genetics, and he urges his followers to maintain the most cordial sympathy and connection with workers in other fields—first the chemical physiologists, then the microscopists who study the minute features of the germ-cells, and also with specialists in all the other branches of biology

We find in Professor Bateson's work no tendency to belittle the work of Darwin, his illustrious predecessor, though, indeed, he has had some very stern tussles with some of the modern Darwinians so-called. Nor do we find him claiming for genetic research more than it is yet entitled to, or may ever be entitled to. In his large book he writes: "Mendelism . . . provides no fresh clue to the problem of Adaptation. . . . That the variations are controlled by physiological law, we have now experimental proof, but that this control is guided ever so little in response to the needs of Adaptation there is not the smallest sign." The principle of natural selection may thus remain, as helping us to understand adaptation, though far more limited in scope than used to be supposed.

It has been obvious now for several years to all students of organic evolution that the principles of that subject require fresh discussion from the beginning. Thought and knowledge have themselves evolved since Darwin wrote, more than fifty years ago. For this task Professor Bateson is evidently the appointed man.

Conspicuous among the deeper questions, upon which as yet we have far too little exact knowledge, are those dealing with the nature and heredity of sex. Upon this subject Professor Bateson delivered an important series of lectures at the Royal Institution early in 1913, and during their course he clearly showed how genetics, in the case of man, furnishes the sole basis for a scientific eugenics.

LOUIS DANIEL BEAUPERTHUY

A Wonderful Officer of Health

Louis Daniel Beauperthuy was a heroic pioneer in the struggle of the white races against the deadly diseases of the tropics. Working at a time when men were not prepared for the great advance he made, his name fell into obscurity, but it has recently been recovered and glorified by Englishmen. Beauperthuy was born in the tropical island of Guadeloupe, in the West Indies, in 1803 He studied medicine in Paris, and became a physician with a strong biological turn of mind, and a skilful user of the microscope. In studying a disease, he would follow it up, in no matter what country it broke out. It was thus with that scourge of the American tropics—

yellow fever. Whenever an epidemic of it occurred in the islands of the West Indies, he set off to make researches on the spot. In middle age, we find him at Cumana, in Venezuela, where a particularly virulent outbreak was ravaging the coast. He had then been making microscopic studies of the blood and secretions in various types of fevers for fourteen years, and the authorities appointed him a health officer. By 1856 he was able to draw the main outlines of a discovery that is destined, as we are just beginning to perceive, to have an extraordinary effect on the destinies of mankind.

"Marshes do not cause in man the slightest indisposition in equatorial and inter-tropical regions, notorious for their unhealthiness. Nor is it the putrescence of water that produces the unhealthiness. *It is the presence of mosquitoes.* Remittent, intermittent, and pernicious fevers, just like yellow fever, have as their cause an animal or vegeto-animal virus, the introduction of which into the human body is brought about by inoculation. The mosquito plunges its proboscis into the skin and introduces a poison that softens and breaks the red blood corpuscules. Intermittent fevers disappear or lose much of their severity in upland regions which have few of these insects."

Never in the history of medicine has so carefully thought out a prognostication received such remarkable scientific confirmation. Having practically solved the problem of the chief diseases of the tropics, Beauperthuy took up the study of leprosy. He died at this work in British Guiana, September 3, 1871. The value of his work was not recognised until some British men of science lately found that certain mosquitos and flies were the carriers of microscopic agents of diseases.

SIR CHARLES BELL
The Founder of Our Knowledge of Health

Sir Charles Bell was born in Edinburgh in November, 1774. His father was a clergyman, and his mother, the daughter of a clergyman, was a woman of rare qualities. She had six children, three of whom rose to eminence. Charles was her youngest son. From the Royal High School young Bell proceeded to the university of his native city, and thence to the dissecting-room and surgery of his elder brother, John Bell, who was already well known. Bell, however, never allowed that he had received any real education but from his mother.

She drew well, and the boy was naturally apt in the important business, as it then was, of drawing the facts which dissection revealed. These were the days before photography, and frozen sections, and the issue of anatomical plates prepared for use with the stereoscope, in order to get impressions of structure in natural relief. In an hour, now, the student may see, and display to others, more than would have cost Bell weeks of labour. For several years he devoted himself to this kind of work, until, to the lasting discredit of those in authority in Edinburgh, the jealousy of his seniors excluded him from any opportunity of continuing his work there; and when he was exactly thirty years old he migrated to London, where his knowledge, enthusiasm, and skill soon won for him great success as a teacher of anatomy to surgeons and artists, and as a surgeon.

"Surface markings" and operation fees, however, were not enough to satisfy the mind of so original a student as Bell. For him the body and all its details, superficial and deep, had meaning, and it was to the elucidation of Design, in the great sense, that his work was really devoted. Even before he came to London he had been led to study the nervous and muscular apparatus of the face and associated parts, not merely as anatomical facts, but as means for the expression of *psychical* facts. Hence his famous book, the "Anatomy and Philosophy of Expression," wherein he showed how the seventh or facial pair of cranial nerves, in man as in many of the lower animals, controls a numerous and complete group of tiny muscles, which were called by him the "muscles of expression," and which play a quite extraordinary part in the mutual relations of mankind. Paralysis of this nerve is now known as "Bell's paralysis."

Here is Darwin's verdict on his great predecessor in the study of expression. "He may with justice be said not only to have laid the foundations of the subject as a branch of science, but to have built up a noble structure." Darwin, too, quotes the opinion of a French student. "The book of Charles Bell ought to be studied by whoever ventured to discuss the visage of man, by philosophers as well as artists, for, under a lighter appearance and under the guise of æsthetics, this is one of the most beautiful monuments of the science which deals with the relations between the physical and the psychical."

These opinions are the more significant because of the fundamental opposition

between Bell and his famous successor. Bell believed and taught, and sought by his researches to demonstrate, that man was specially created as he now is ; indeed, the theory of special creation never had a doughtier champion than this close and searching student of the highest existing form of living organism. Darwin, on the other hand, believed that the human body had been evolved on mechanical principles, and his study of expression thus leads him to a conclusion directly opposed to Bell's. Darwin, however, was no common controversialist ; there have been many cleverer men, but never one who was truer or more generous.

Measured by influence upon the progress of exact knowledge, all the earlier and latter work of Bell must be held secondary, compared with his great inquiry into the functions of the individual nerves which proceed to the body from the brain and spinal cord. In some cases the individual functions of these nerves were already known, as in the case of the seventh cranial or facial pair, studied by Bell himself. His great discovery dates from the year 1807, in which he published his essential results, finding order in chaos, and making possible thereby all further advance in our knowledge of functions and co-ordination of the nervous system.

Bell showed that there are nerves entirely sensory in function, nerves entirely motor, and mixed nerves which contain both kinds of fibres. This was in itself an enormous advance upon the view that any fibre of any nerve might act in any capacity ; and it led to the recognition of motor and sensory nerve-cells, from which alone proceed motor and sensory nerve-fibres respectively. From this moment a real anatomy and physiology of the nervous system became possible. Finally, and most celebrated of all, came the discovery of the nature of the two roots of a spinal nerve. From the spinal cord, in man and the higher animals, there proceed numerous pairs of nerves, each of which nerves is formed by the union of two roots, one springing from near the front of the cord and another from a point further back.

By dividing the roots of such nerves in living animals, Bell found that the anterior roots are always motor, and the posterior roots always sensory, the nerves formed by their union being thus mixed nerves. This discovery was of crucial importance, not merely for anatomy, but in the practice of medicine and surgery, since from it has sprung that knowledge of the nervous system which enables us to recognise the meaning of a patient's symptoms of paralysis or loss of sensation, and to treat the thus found cause upon which his symptoms depend.

Though this part of Bell's work will always rank first for its practical significance, yet more was to follow, perhaps no less interesting from an even higher standpoint. As a devoted student of the mechanism of the body, Bell was entirely convinced that, in a thousand and one details, it showed evidence of Creative Design. In no other way could he account for the instances of co-ordination, of harmony, and of what we should now call adaptation, which he encountered. Hence, in 1833, he wrote his celebrated Bridgewater treatise on " The Hand," wherein the great anatomist dealt with " its mechanism and vital endowments as evincing design."

In 1836 Edinburgh paid Bell the tardy honour of recalling him as Professor of Surgery, and he held that Chair during the last six years of his life. He died, near Worcester, on April 28, 1842, and his body was buried in Hallows churchyard, under the following epitaph, written by his famous fellow-countryman Jeffrey: "Sacred to the memory of Sir Charles Bell, who, after unfolding, with unrivalled sagacity, patience, and success, the wonderful structure of our mortal bodies, esteemed lightly of his latest discoveries, except only as they tended to impress himself and others with a deeper sense of the infinite wisdom and ineffable goodness of the Almighty Creator."

There was a long period after Bell's death during which the ideas of Paley, which he had illustrated and restated so extensively, were the object of the most unqualified criticism on the part of the pioneers of science. Where Bell saw, as in the hand, manifold and indisputable evidence of creative design, the evolutionists saw only the outcome of a happy chapter of accidents. No modern biologist would now return to the views of Bell, as he stated them, but today we have many times as much evidence of what he called creative design as was known to him ; and if we need to alter his conclusions, it will not be in order to question his conviction that the body, of which he was an almost unrivalled student in all time, shows innumerable signs of purpose, but in order to maintain that those signs of purpose are due not to a manufacturer acting from without, but to a creative evolution from within.

CLAUDE BERNARD

The Chemist-Explorer Within the Body

Claude Bernard was born near Villefranche, in France, on July 12, 1813. After a period, during which it seemed uncertain whether he was to become a playwright or a man of science, he went to Paris, and there became a pupil of the great Magendie, a notable figure among those who have applied experimental methods to the observation of living tissues. On its external aspect, Bernard's career thereafter was of no unusual kind. At various times he held Chairs of Physiology at the Collège de France, the Sorbonne, and the Natural History Museum.

But his teaching was merely the economic necessity of so many original students before his time and since. However, Bernard found time for much research, and also for the writing and delivery of a large number of lectures upon his results and their significance. He will always rank as the great master of chemical physiology in its broader outlines; and no student of digestion, excretion, the disorders of chemistry within the body, or the means of dealing with them, can count as other than a follower of Bernard.

His principal work was done and published in that extraordinary decade the first of the second half of the nineteenth century, which saw the principal and essential work of such men as Darwin, Spencer, and Bain. By means of carefully devised and conducted experiments upon living animals, Bernard was enabled to reveal certain functions of such glands as the liver and the pancreas, which are possessed also by man; and, in fact, his results apply to organs of this type throughout the whole long range of animal forms in which they occur. They opened the way not merely to a far profounder understanding of the methods of the animal body, the subtlety and resource of its constitution and working, but also to the comprehension of such diseases as diabetes, which depend upon chemical errors, and which, until Bernard's time, could not possibly be understood, or even adequately defined. Thus to him we clearly owe the very great contrast between modern methods of treating and alleviating diabetes and allied diseases of nutrition compared with those of the past.

The French Academy of Sciences awarded Bernard a prize for his first great discovery—that of the functions of the pancreas. This large and important gland, common to man and the higher animals far down the scale, had long been a mystery to physiologists. Claude Bernard contrived to collect some of the pancreatic juice, so that it could be studied—no easy task in his time, and one which had been attempted without any effective success nearly two centuries earlier. Of Bernard's work on this gland, his English biographer, the Cambridge physiologist, Sir Michael Foster, says: "Bernard at one stroke made clear its threefold action. He showed that it on the one hand emulsified, and on the other hand split up into fatty acids and glycerine, the neutral fats; he clearly proved that it had a powerful action on starch, converting it into sugar; and lastly, he laid bare its remarkable action on proteid matters."

Bernard thus went a long way, but he stopped short of the whole truth, for it was left to his successors to discover, not long after his death, that the pancreas also has another kind of juice, never yet seen or isolated, which is called its "internal secretion," and which passes into the blood, with profound effects upon the chemistry of sugar taken in the food.

It was in 1853 that Bernard published, in Paris, his "New Function of the Liver." For ages it had been known that the liver produces bile or "gall," which passes into a kind of temporary receptacle called the gall bladder. The older physiologists had supposed that the liver was closely connected with certain states of mind and feeling, as, for instance, courage and amorous feeling. The terms "chicken-livered," "lily-livered," and many allusions in Shakespeare and elsewhere will occur to the reader. Bernard set to work to find the facts. By feeding two dogs, one on a diet which contained sugar, and another on a diet which contained none, and then killing them, he found to his great surprise that, even in the latter dog, sugar occurred in the blood leaving the liver, though none was present in the blood entering it. He further found that the liver stores up sugar which reaches it from the bowel (when the diet makes that possible), and serves it out to the blood as the body requires it. The dog that had not been fed on sugar for eight days was, nevertheless, getting a supply of sugar in the blood that nourished it, derived from the store in the liver.

Bernard found that the liver modifies the sugar which reaches it, turning it into a substance called glycogen, which simply means the "sugar-maker." Enough is

allowed to pass on for the bodily needs—sugar being a chief source of energy in the animal body. But when and if the amount of sugar in the blood, as it leaves the liver to go to the body at large, is insufficient, the liver transforms part of its store of glycogen back into sugar, and sends it forward for use.

This was Claude Bernard's epoch-making discovery of what is called the "glycogenic function" of the liver. He showed what no one had suspected, that this organ, which produces an obvious secretion and discharges it by an appropriate canal, also produces an "internal secretion" of a vastly subtler kind, and in relatively infinitesimal quantities, which is capable of profoundly affecting the chemistry of nutrition—and without which, in point of fact, we could not live.

Nor is that discovery by any means all. Bernard had given us a clue to a new world in the all but infinite cosmos of the living body. Internal secretions were soon sought elsewhere, and found; and some of them, like that of the thyroid gland, are now among the most invaluable and almost magical remedies known to medical science.

Last, we must rank Bernard's great discovery that the size of the smaller arteries, or arterioles, is regulated by the action of two sets of nerves, one of which causes the arteries to contract, while the other causes them to dilate. The parts of the body—brain, muscle, skin, gland, whatever it be—supplied with blood from the arteries in question are thus starved or flushed as the case may be. Only the professed student of physiology can realise at all adequately where we should be today if we did not know of the existence of the vasomotor system.

Claude Bernard died in Paris on February 10, 1878, and was the first Frenchman to receive the honour of a public funeral. But the children of his fertile mind and faithful hand walk the earth in every land today.

MARIE FRANÇOIS XAVIER BICHAT

Founder of the Science of Minute Anatomy

Marie Bichat was born at Thoirette, in France, in 1771, the son of a medical father, under whose direction the boy soon reached the clinique of Petit, the famous surgeon of Lyons. In 1793 he went to Paris, where, after a few years, he became a successful teacher of surgery. He was already in the grip of consumption, but the disease could not prevent him from thinking and writing. His great works, containing the ideas which will always preserve his name, are his treatise on "Life and Death," published in 1800, and his "General Anatomy," published in the following year. He was then only thirty, and he was about to die.

To Bichat we owe the great name of Vitalism, which expresses the essence of his teaching. The familiar expression "vital force" is also his. Owing to the dominance of mechanical theories of life during the latter part of the nineteenth century, in England and Germany especially, few students in this country are aware of the place which Bichat must soon be recognised again to hold in the history of biology. His fellow-countrymen have always recognised his supreme genius, but the reader will vainly seek for any appreciation, or even a clear statement of Bichat's philosophy, in the standard works of reference in this country. It is also a singular fact, to which French critics must surely have drawn attention, that Bergson, the most conspicuous modern representative of Bichat's school, does not appear to be acquainted with his predecessor's work, and does not mention his name.

Only in the pages of Dr. Theodore Merz, of Newcastle, who has long been and still is writing his great work on the "History of European Thought in the Nineteenth Century," will the English reader find any adequate account of this illustrious youth, who, while himself dying of a deadly disease, examined six hundred corpses within a few years in order to learn what they could teach him.

Bichat is known to all students of medicine as, in the first place, the founder of the science of minute anatomy—nowadays called histology, or the anatomy of the tissues. He had no miscroscope in those days that could be trusted, but he founded histology none the less. Directly from his study of the structure of membranes and tissues, in health and in disease, Bichat concluded that vital processes are essentially opposed and antagonistic to those of the not-living world. Hence his celebrated definition of life as "the sum of the functions which resist death."

"There are," says Bichat, "in Nature two classes of things, two classes of properties, two classes of sciences. Things are organic or inorganic, their properties are vital or non-vital, the sciences are physiological or physical." Had Bichat lived another forty years, he would doubtless have modified and greatly extended his

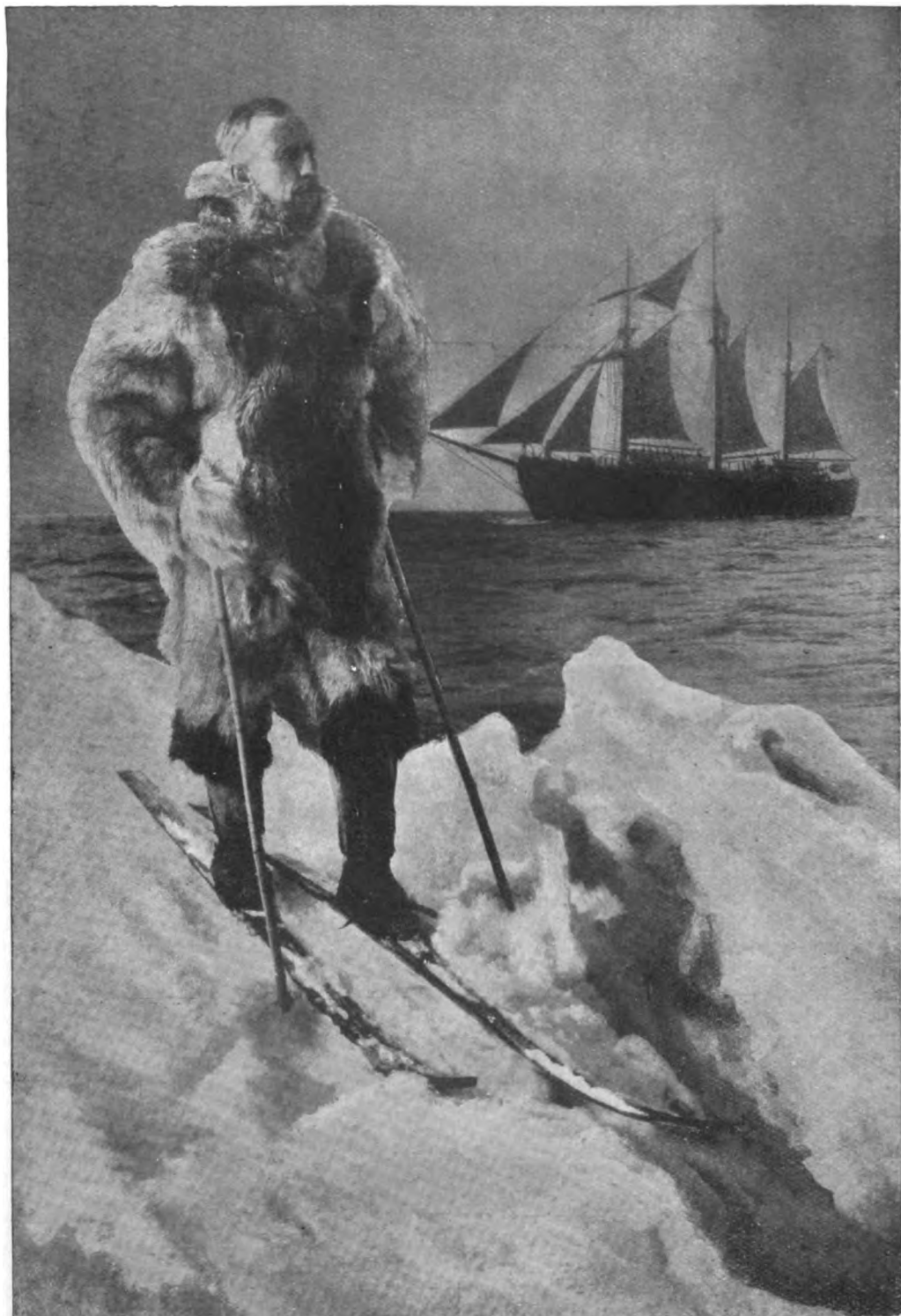
views, especially because he would have become acquainted with the discoveries of Sir Charles Bell and with the results which experimental physiology was soon able to obtain. At the stage to which alone he was permitted to advance his thought, Bichat's "Vitalism" lacked much which we realise today, and which may perhaps excuse those who prefer the term "Neo-Vitalism" for the ascendent doctrine of modern biology. Bichat did not know that those who built on the foundations which, as the first great student of living tissues, he himself laid would find that the forces and laws of the physical or non-vital world are constantly illustrated in living tissues, and therefore that, in the form he gave it, his statement, quoted above, cannot be maintained.

After Bichat's time, but not long after, the cell-structure of living beings was discovered. Then, again, the chemists and physicists—Bichat was neither—such as Liebig and Helmholtz, began to suggest, and finally to demonstrate, that physical energies are transformed in the living body, and that in no circumstances can any living organism be found to disobey the physical law of the conservation of energy. Bichat's term "vital force," or "vital principle," required restatement in the light of these discoveries; and the simplest and most popular restatement was simply to dismiss it as nonsense.

The history of Bichat's ideas, even after his death, is in place here—first, because they have in them part of his essential life; and, second, because we cannot "place" this great man, or understand the neglect of him today, even in such an astonishing case as that of Professor Bergson, unless we are aware of the vicissitudes to which his theories became subject, for several decades after his death. While the many rejected them, the few were wiser. Thus, for instance, the great German physiologist Du Bois-Reymond, twenty-five years after earlier pronouncements in which he leaned to the mechanical school, published in 1880 his famous "Seven Riddles of the World," in which he avowed himself a vitalist, with cogent reasons therefor. Liebig to the end remained a vitalist, and so did Virchow, the founder of the cellular pathology, which the lack of a microscope had concealed from the eyes even of Bichat.

Today, however, the wheel is coming full circle; and though such leaders of modern biological thought as Bergson, Driesch, and McDougall, representing France, Germany, and England, have one and all failed even to mention Bichat in their principal works, and though some excuse for this remarkable neglect may perhaps be found, yet it is certain that this profound young student really belongs to the place in which Dr. Merz recognises him. The excuse for his neglect doubtless consists in the fact that his idea of the "vital force" must be abandoned. There is *no* vital force in the sense of a force similar to physical forces but opposed to them. This the physicists have proved, and, indeed, the mere term "vital force" instantly enrages all members of the mechanical school. But a vital *something* requires to be recognised more surely now than when Bichat wrote.

What the modern followers of Bichat—above all, Bergson and McDougall—maintain is the existence of a vital principle which is by no means merely a physical force peculiar to living creatures, yet comparable to other physical forces, but is of another order altogether—of the order of mind, or the psychical. Thus vitalism returns, though with a notable difference; and though the stream of biological thought will never flow back to Bichat, we shall be very ungrateful and careless if we do not recognise the place of this marvellous boy in the great sequence of those from whom our thought and knowledge flow.

His pupils adored him. His last great work, of which he published only two volumes, was completed by the devotion of his assistants after his death. He knew the meaning of gratitude. When he was twenty-four, his admiring and unselfish surgical teacher in Paris died suddenly, and Bichat maintained and was a son to his widow to the end. She nursed him upon his death-bed. Nothing had been able to stop his work for long; severe attacks of hæmorrhage from the lungs delayed him only while they lasted. He needed rest, but he took none. He needed pure air, but he would not leave his place of labour in the dissecting-room, of all places, where many a consumptive before and since Bichat's time has hastened his end. He died in Paris, on July 22, 1802, at the age of thirty-one, and his funeral was attended by more than six hundred of his pupils, and by many representatives of the profession which he adorned and exalted. Napoleon, a consummate judge of genius, had his bust placed in the Hôtel Dieu, the great hospital of Paris, and the visitor may look upon a statue of him in the quadrangle of the present school of medicine.

THE FAMOUS NORWEGIAN EXPLORER ROALD AMUNDSEN, WITH HIS VESSEL, "THE FRAM," WHICH TOOK HIM TO THE ANTARCTIC SEAS

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EXPLORERS

DUKE OF THE ABRUZZI

The Adventurous Son of a King

THE Duke of the Abruzzi, Prince Luigi Amedeo Giuseppe Maria Ferdinando Francesco, began his life of adventure in his cradle. At his birth, in Madrid on January 29, 1873, he was the son of a reigning king; a few days afterwards he was merely an obscure scion of the House of Savoy. His father, a son of Victor Emmanuel of Italy, was elected to the Spanish throne in 1870; but a republican revolution broke out, and King Amadeus abdicated in February, 1873, and, as Duke of Aosta, returned to Italy. His adventurous son was educated in the Naval Academy at Leghorn, where he distinguished himself by his modesty, his democratic manners, and his brilliant ability. A tall, lightly-built, and silent boy, he felt no attraction to the aristocratic life that opened out to him as nephew of the King of Italy. A life of mingled study and adventure was what he aimed at, and while still a boy he distinguished himself by scaling the peaks of the Demoiselles Anglaises on the Mont Blanc range. The heights were called "The English Girls" because of their coldness and inaccessibility. The young Duke was the first to overcome them.

After finishing his studies as a naval officer, the Duke disappeared from Italian society and completed his education in his own way by a tour round the world. On his return he was still invisible to courtiers and clubmen; his days were spent in incessant study and excursions in the Alps. The real fever of adventure was now stirring in his blood, and he was carefully planning out his first great achievement. On the borders of Canada and Alaska there is an Arctic mountain, St. Elias—one of the hardest climbs in the world. Many men had vainly attempted to climb it. The ice began almost at its foot, and the high rocks were shrouded in eternal mist.

The young Duke, however, conquered the mountain before seeing it. Following the course of action he adopted afterwards in his Polar and Equatorial expeditions, he collected all available sources of information, studied them for some months, and then drew up a plan of campaign containing all the elements of success. He brought the science of strategy to bear upon the work of exploration, with the result that he ascended Mount St. Elias with remarkable ease in 1897. Then, having tasted the stern joy of Arctic adventure, he resolved to plant the Italian flag on the North Pole. After a long course of study at home, he reduced the problem to a scientific calculation, and went to Norway by a sealing-boat for the voyage. Here he made a mistake by purchasing a vessel that Nansen had rejected as being too lightly built to resist the pressure of the Northern ice. The little ship was wrecked in the moving ice off the coast of Franz Josef's Archipelago, and the Duke and his men had to camp out in tents. Had not a spiral movement of the icefield lifted the wrecked ship on to a solid plateau of ice, it is probable that none of the party would have survived. The disaster entirely upset the Duke's plans, for he had provisioned the ship for five years, with the intention of taking it as far north as possible, and using it as the base of his operations.

Matters were further upset by an accident that happened to the Duke while training his dogs for his sledge expeditions. One of his hands turned white and then black, and his fingers were so frost-bitten that the surgeon thought he would have to amputate the whole arm. The brave young explorer was compelled to remain for months in the shelter of a tent, and by careful nursing and treatment he escaped with the loss of the tips of his fingers. During his illness he sent his second in command, Captain Cagni, on a sledge raid to the Pole. Cagni went on till nothing remained to eat except dog food.

He attained 86 degrees 33 minutes North, and this remained the record for Arctic exploration until Peary won right to the Pole. Cagni was absent 104 days in the summer of 1899; his return journey was one of great peril and hardship. The plain of ice across which he had gone disappeared, leaving a sea full of floating islands of ice. The exploring party rigged up sails on these islands, but, being unable to steer them, they had to leave hurriedly a piece of ice that began to drift in the wrong direction, and jump to another that seemed to be going the way they wanted. By this extraordinary means of navigation, the ship was reached; and as it had been repaired by the carpenters, the Duke and his men were able to get safely back to Italy.

An unhappy love affair with Miss Katherine Elkins, the beautiful daughter of an American senator, drove the young Duke forth in search of further adventures. He fought hard for the right to marry the lady with whom he had fallen in love, but the opposition of the Royal ladies of his House was too strong for him to overcome.

In search of excitement, he turned to the Mountains of the Moon, on the borders of Uganda and the Congo Free State. Here, beneath the scorching heat of the Equator, rose the snow-crowned height of Ruwenzori, discovered by Stanley in 1887, but still unscaled by man. Some men of science, sent by the Natural History Branch from the British Museum, were attempting to conquer the virgin peak of the Equator when the Duke of the Abruzzi arrived on the scene. A bold plan of attack that he had drawn after his study was so well prepared that he carried off the honour of the climb under the nose of the Englishmen. What would have been merely a piece of laborious and well-planned work of exploration was changed into a terrible adventure by a leopard that took a personal interest in the scientific Duke. Three years later, in 1909, the same explorer ascended Mount Godwin-Austen, in the Karakoram Mountains in Asia. At the age of forty, the Duke of the Abruzzi is the most popular man in Italy. Even the King is not more loved and admired.

ROALD AMUNDSEN
Discoverer of the South Pole

Captain Roald Amundsen, the discoverer of the North-Western Passage and the geographical South Pole, is the son of a Norwegian shipowner. Born on July 16, 1872, at Borge, Smaalenene, on Christiania Fiord, he comes of a family of sailors. Against his wishes, he was sent to study medicine in Christiania University. It was in the days when the first achievements of Nansen had begun to stir the slumbering imagination of the descendants of the ancient Vikings. The lads of Norway fell to dreaming of the deeds of Eric the Red, who sailed from Norway to Iceland, from Iceland to Greenland, from Greenland to America, in the wild old pagan times when other Vikings were harrying England and Ireland, and conquering Normandy. It was a renaissance of the spirit of adventure, and Amundsen's career was changed by it. Like many other Norwegians, he resolved to become an explorer, and, throwing up his post, he went as a deck hand on a sealing-ship to gain experience of Arctic navigation.

He was already an eager student of the scientific problems of the icy wastes of the North. And when he returned from his first voyages in pursuit of seals and whales and practical experience, he put himself under the tuition of Dr. von Neumayer, one of the greatest living authorities on magnetism. After devoting a long period to this kind of study, Amundsen went as first officer of the "Belgica" to the Antarctic regions—still in search of scientific and practical knowledge. The little ship crossed the Antarctic Circle on February 15, 1898, and was caught by the ice-floe, and held prisoner for a year. So her mate was among the first of men to experience the long darkness of the Antarctic night. There was little light on the ship, and the expedition suffered greatly from inadequate food.

On returning to Norway, Amundsen spent some time in navigating the icy seas of the North, and by 1902 he had learned all there was to know about the most difficult and perilous kind of seamanship. So the next year he began his own great work of extending the boundaries of human knowledge and power by setting out to find the North-West Passage, marked by the graves of Franklin and other brave but baffled English explorers. He combined the methods of the ancient Vikings with the machinery of the twentieth century. Instead of taking a large crew in a great ship loaded with provisions, he went with six men in a tiny sealing craft, the "Gjoa," of 46 tons. The old, strong sealing-boat was, however, fitted with a petroleum motor of 39 horse-power. She left Christiania on June 17, 1903, and crossed the Atlantic, sailing between Greenland and Baffin Land. On August 24, the little "Gjoa" entered Peel Sound, making slow progress through

the ice along the foggy coast of Boothia, where Franklin died.

Here Amundsen and his men had a very narrow escape from the same terrible death from starvation that befell the English searchers after the North-West Passage. While the "Gjoa" was anchored by a small island, the men on shore saw a pillar of flame shoot up from the engine-room of the ship. There were seven thousand gallons of petroleum on board, besides large quantities of gunpowder. It looked as if the vessel were doomed, and the loss of the vessel meant the loss of lives. Fortunately, the engineer had not left his post, and as he battled with the fire the men ashore hurried to his aid, and the flames were got under. Some cotton had become saturated with petroleum, and had ignited through contact with the engine.

Soon after this too exciting adventure, Amundsen set up his winter quarters some distance below the Magnetic Pole, and spent two winters making a scientific study of this centre of interest to all navigators. For nineteen months he conducted continuous magnetic observations, which were kept up night and day, without interruption, for this long period. He found that the Magnetic Pole, that had first been located by Ross, was not a fixed point on the earth, but a shifting centre of mysterious force. The results of his lengthy and delicate studies were of very high importance in science. They were, indeed, much more important than the discovery of the geographical Pole itself.

At the northern focus of terrestrial magnetism, Amundsen became very friendly with some unknown tribes of Eskimos, one of them being strangely of the Red Indian type. From them he learnt how to build snow-houses; and one young Eskimo bravely travelled 1500 miles to bring the explorer a pack of dogs for sledge work.

All this time, the North-West Passage was open to Amundsen, but with praiseworthy restraint he put off accomplishing it until his magnetic studies were completed. He owed his success in finding the sea channel to the excellence of his knowledge of magnetism, and to the exquisite magnetic instruments he had brought with him. For when he arrived at a point where all students of Polar exploration said, "Go north, and find the open sea," he looked at his instruments and found that they indicated "Go south." Had he gone north, he would have failed like other men, but by turning south he found an open way along the extreme edge of Canada. On August 30, 1906, he entered Behring Strait; then the next day he called at the gold-digging town of Nome, in Alaska, and met with an enthusiastic reception. So the first voyage through the North-West Passage came to a happy end.

Amundsen's next aim was to win to the geographical North Pole, and he fitted out Nansen's old ship, the "Fram," for this purpose. But, hearing of Peary's achievement, he turned south, and raced against the ill-fated Captain Scott for the honour of attaining the geographical South Pole. Taking the "Fram" to the great ice-barrier, he reached the Bay of Whales, charted by Ross in 1841. The work of laying depots for the march to the Pole was completed in April, 1911, and so well was everything planned by the experienced explorer that the affair was a pleasant excursion. There was no suffering from hunger and exhaustion, and the health of the men and sledge-dogs remained good. There was not even need for the party to go on fixed rations. The weather was very favourable, and on October 20 the start was made. On November 17 the junction of the ice barrier and the land was reached, and Amundsen and his men began to climb the great Polar tableland. The greatest height, 10,750 feet, was reached on December 6, and soon afterwards the land began to slope down towards the Pole. On December 16, 1911, the expedition camped on the South Pole. Observations were taken hourly by four men for twenty-four hours, and the plateau was given the name of King Haakon VII. Captain Amundsen is now planning a five years' trip entirely by sea to the North Pole. He wishes to prove the existence of a great North Polar Ocean.

WILLIAM BAFFIN
Greatest Polar Seaman of Elizabethan Times

William Baffin, the greatest Polar explorer in the glorious age of Shakespeare, was a Londoner of humble birth. He was born somewhere about 1584. Baffin got so near to the Pole that for hundreds of years no one followed him, and no one believed in his discoveries. He made excellent maps of the icy seas through which he sailed, but geographers would not believe in his voyages, or make use of the information he obtained. But now that Peary has laboured for years on the scene of Baffin's heroic adventure, and won to the Pole thereby, we can only regret that no one took the trouble in Baffin's lifetime to find out more about this great Elizabethan.

He seems to have been born of poor seafaring folk on the riverside of London; he was uneducated, but by self-teaching he became a graceful writer, a mathematician, and the most scientific navigator in Europe. Even Barentz cannot compare with him in science, but, unhappily, we do not know how he won his extraordinary knowledge and developed his talent for inventing devices to do what no other man could do. Our knowledge of terrestrial magnetism in the sixteenth century depends entirely upon his observations made in the neighbourhood of the North Magnetic Pole. By studying the sun and moon and stars in the high Polar regions he fixed his positions with such accuracy that explorers in the nineteenth century were able to follow him easily. He emerges into the light of history in 1612, when he sailed as pilot under Captain Hall, of Hull, on a voyage of discovery to Greenland. While examining the west coast of this great Polar island the Englishmen were attacked by Eskimos; Hall was killed, and the expedition returned home.

Baffin then entered the service of the Muscovy Company, an enterprising body of London merchants, at the head of whom was Sir Thomas Smith. Smith was the soul of most of the English Polar expeditions of his age; he fitted out ship after ship for the discovery of a Polar passage. to China. Baffin served as pilot on two voyages to Spitzbergen, in 1613 and 1614. Then he was appointed pilot of a little ship, the "Discovery," of 55 tons, with a crew of sixteen men. He set sail from Gravesend on March 18, 1615, on an attempt to find the North-West Passage by the north of Canada, but he was stopped by ice at the end of Hudson Strait, and only reached the western end of Southampton Island. But Sir Thomas Smith was not daunted by this want of success. The next year the "Discovery" was again fitted out, and, leaving Gravesend on March 26, 1616, Baffin set out on his last and most important Arctic voyage. On rounding Newfoundland he kept straight to the north, avoiding Hudson's route. Passing down the strait that Davis had discovered in 1587, he got clear of the ice and sailed into the vast expanse of Baffin Bay.

In this unexplored region Baffin saw thousands of whales and seals and walruses. The whales especially were so little frightened that he was able to sail his ship close up to them. On some islands he met Eskimos, who brought him a great quantity of horns, possibly obtained from the musk oxen wandering amid the snow of northern Canada. At the extreme north of the bay he discovered a sound leading to the North Pole, which he called Smith's Sound, in honour of Sir Thomas Smith. It was through this sound that Peary travelled in 1909, and reached the North Pole. Baffin was not greatly interested in it, because it led past the northern coast of Greenland back into the North Atlantic Ocean. What Baffin wanted was a westerly passage to China. He found it at the place he named Lancaster Sound, but the sea began to freeze and the crew became ill with scurvy, so he was forced, at the peril of being caught by the ice and starved to death, to return to England.

He found no one in England ready to put money for another expedition. But he was not a man to be daunted by want of money. He resolved to sail to China, as a working pilot, and strive for an opportunity of attacking the problem from the northern coast of China. Helped, no doubt, by Sir Thomas Smith, he obtained the command of the "London," one of the ships of the East India fleet. She set sail from Gravesend on March 25, 1620, and, with the rest of the fleet, sailed south to the Cape of Good Hope, and then turned northward by Madagascar. Here news was received that a combined force of Portuguese and Dutch ships was waiting at the entrance of the Persian Gulf to cut off and attack the English vessels. But the Englishmen did not wait to be attacked; they went in search of the enemy, and found them. The English admiral stayed with Baffin on the "London," and was killed by a great shot, but before he died had put the Dutchmen and Portuguese to flight.

The Portuguese had built a strong fort at Ormuz, from which they dominated the country and oppressed the people. The Shah of Persia implored the Englishmen to help him against the Portuguese; so the four English ships anchored off Ormuz, landed their guns, and threw up batteries. On January 23, 1622, Baffin went on shore with his mathematical instruments to take the height and distance of the castle wall, and so find the range for his guns. But as he was making his observations a shot from the castle struck him, and prevented him from discovering Behring Strait, for he died at once in great agony. A few days afterwards the English guns breached the fort, and the Portuguese surrendered to the English. So began our dominion in the Persian Gulf.

SIR SAMUEL WHITE BAKER

Discoverer of Lake Albert Nyanza

Sir Samuel White Baker, the African explorer who discovered the Albert Nyanza, was born in London, June 8, 1821. His parents wished him to become a business man, but after working a little while in an office, Baker came to the conclusion that a life in the open air suited him best. His father, happily, had some property in the island of Mauritius; and having seen Samuel married at the age of twenty-two, and, as he hoped, settled down in life, he sent the young man to look after his tropical estate. Baker, however, had a passion for travel and adventure and experiment. His temperament was that of a pioneer, and he was filled with a restless energy that wore him out when it could not find an outlet.

In two years he exhausted the romance of Mauritius, and went to Ceylon on a hunting expedition. It struck him that the highland of Nawara Eliya, with its temperate climate, was an excellent place for English settlers. So he founded an agricultural settlement there, and brought emigrants from England, and imported fine breeds of cattle, and made the new settlement rapidly into a successful piece of colonising work. His health, however, broke down, owing as much to his hunting expeditions in the jungle as to his labour in organising the little farming colony. He returned to England in 1855, with his wife and four children, and soon after his return his wife died.

SIR SAMUEL BAKER

Still in search of adventure and work, he wandered about Turkey and the Crimea, and found something to do in directing the construction of a railway across the Dobrudsha, a district of Roumania beside the Black Sea. Having completed this remarkable monument of his versatility, he roamed about Asia Minor and the Balkans, still in quest of excitement and toil. The excitement he found in Hungary on meeting Miss Florence von Sass. A woman of his own stamp—adventurous, hardy, and scornful of ease—she married the nomadic Londoner in 1860, and then started with him on a journey into Central Africa, to discover the sources of the Nile.

They set out from Cairo in April, 1861, and spent a year exploring Abyssinia, and ascertaining the position of the chief tributaries of the Nile in this region.

Then in December, 1862, Mr. and Mrs. Baker started from Khartum, and tracked the course of the White Nile. After travelling for two months, they reached Gondokoro, and there met Speke and Grant returning northward from the south after the discovery of the Victoria Nyanza. The success of the East African expedition at first made Baker afraid that there was nothing left for him to discover. Speke and Grant, however, had heard native rumours of another great lake to the north-west of Victoria Nyanza. They told Mr. and Mrs. Baker of these rumours, and the married explorers set out to the wild, unknown tropical country in search of the mysterious waters. It was not until March 14, 1864, that the lake was sighted, and after surveying the country around it, and naming it the Albert Nyanza, the Bakers set out on their return journey. After many difficulties and perils they reached Khartum safely in May, 1865, and proceeded to England. Both the Royal Geographical Society and the Paris Geographical Society awarded Baker with a gold medal; and in August, 1866, he received the honour of knighthood.

LADY BAKER

Three years afterwards, the Khedive of Egypt offered him the command of an army for an expedition to Central Africa to suppress the slave trade there, and open up the country to trade with Europeans. A force of 1700 Egyptian troops was placed at his orders; he was given the rank of Pasha, and appointed Governor-General of the new lands at a salary of £10,000 a year. His appointment was only for four years. But during this time he did some splendid work in organising the administration of the new territories. Had the Egyptian Government given him the support he needed, or had he remained longer at his work, the Sudan might not have been lost to the Khedive. But before his task was done he was succeeded by Gordon; and with his wife, who had accompanied him, and helped him in all his hard and wearing labours, he returned to England at the

SIR SAMUEL BAKER AND HIS WIFE FREEING SLAVES

expiration of his period of engagement. In 1879 he explored Cyprus, and afterwards travelled through Syria, India, Japan, and America. But most of his latter life was spent on his estate of Sandford Orleigh, in South Devon, where he died on December 30, 1893.

Sir Samuel was a picturesque writer, and he depicted the stirring incidents in his adventurous career in a series of remarkable books. Among them are—"The Rifle and the Hound in Ceylon," 1853; "Eight Years' Wanderings in Ceylon," 1855; "The Albert Nyanza," 1866; "The Nile Tributaries of Abyssinia," 1867; "Cast Up by the Sea," 1868, a work of fiction; "Ismailia," his narrative of his Central African expedition, in 1874; "Cyprus as I saw it in 1879," and the very interesting "Wild Beasts and their Ways," 1890.

VASCO NUÑEZ DE BALBOA

The Man Who First Travelled Across America

Vasco Nuñez de Balboa, the first man to cross America, was born in 1475. He belonged to a poverty-stricken noble family of Xeres-de-los-Caballeros, in Spain. Fame was won by him in a series of flights from his creditors. He feared a dun more than he feared death. So when Bastidas, a rich man of Cadiz, resolved to grow richer by winning gold in the New World recently discovered by Columbus, Balboa was glad to go with him in search of El Dorado. But Bastidas was unfortunate. He landed at the island of San Domingo, where the governor, already notorious for his infamous conduct to Columbus, arrested the rich merchant on a false charge, and sent him back to Spain.

SIR SAMUEL SETTING OUT FROM M'ROOLI FOR LAKE ALBERT NYANZA WITH HIS ESCORT

Balboa, however, managed to settle in Hayti, and obtain a grant of land and a gang of Indians to work it. But the Spanish adventurer was so unused to handling any sort of wealth that his estate was soon loaded with more debts than it was worth. His creditors began to pester him, and he was anxious to escape from them. An expedition was starting to found a colony on the mainland at Darien, and Balboa, being in very sad circumstances, was naturally eager to join it. Unhappily, there was a law that no insolvent debtor was to board a ship bound for the mainland. But the duns pressed, and the great Spaniard who was to win fame

> "when with eagle eyes
> He stared at the Pacific—and all his men
> Looked at each other with a wild surmise—
> Silent, upon a peak in Darien,"

was equal to the occasion. He ordered a big cask to be rolled on to the ship in which the leader of the expedition sailed. Balboa was in the cask!

On arriving at the mainland, the Spaniards found the natives more warlike than the Indians of the islands, and they were unable to make a conquest. Defeat was followed by dissensions, and the baffled adventurers took refuge at Santa Maria la Antigua, upon the Gulf of Darien, and elected Balboa to command the new colony—the first on the mainland of America. He had won their admiration by his bravery.

He proved to be a good governor; he was just in his treatment of the natives, and he allowed no unnecessary cruelty. By mixing with the Indians he gradually learnt of the existence of a land of gold. Six suns away—six days' journey—he was told, there was another sea that washed the shores of Peru, a land that was very rich in gold. Accordingly, in 1513, he determined to set out in quest of the strange western sea. He assembled a troop of a hundred and ninety volunteer soldiers, and led them over the mountains and through the tropical jungles of the isthmus of Darien. Some warlike tribes tried to bar his way, but he broke through them. After twenty-five days of marching and fighting, the expedition reached a mountain top, from which they descried the vast expanse of the Pacific Ocean. Four days later, Balboa,

SIR SAMUEL BAKER CHARGED BY A WOUNDED ELEPHANT

his drawn sword in one hand and the banner of Castile in the other, advanced to the shore and took possession of the land of Panama upon the Pacific coast.

Balboa crossed the isthmus several times, and always in some new direction.

Unfortunately for Balboa, and perhaps for the Peruvians too, a new governor was appointed over Darien through intrigues at the Spanish Court. He proved a cruel and obstinate man. Balboa endeavoured to make friends with him by marrying his daughter, and the famous explorer was then allowed to go on with his land explorations. But when he began to build ships, and to prepare an armament for the conquest of Peru, the new governor, out of jealousy of the probable success of his subordinate, brought a false charge against him, in 1517, and had him beheaded. The murder retarded the conquest of Peru for twenty-five years, which was something gained for the empire of the Incas, yet it is probable that the most civilised race of America would not have suffered so much under Balboa as it did under Pizarro.

WILLIAM BARENTZ
The First Hero of the Polar Seas

William Barentz, the first true Polar explorer, was a Dutch pilot, born on the island of Terschelling about the middle of the sixteenth century. He was a bold and enterprising seaman, an accurate observer, and a man of education. English sailors had captured the Russian trade by their hardy voyages in search of the North-East Passage to China, and the merchants of Amsterdam resolved to attempt the Polar path to China, by taking a still more northerly route than the English had tried. They asked Barentz to discover for them the icy sea-way to Cathay; and on June 5, 1594, Barentz sailed north from Texel, and sought for a passage through the ice-pack at the extreme north-west edge of Novaya Zemlya. He sailed over 1700 miles, and put his ship about no less than eighty-one times. Taking observations of the sun with unusual accuracy, he fixed the latitudes of the Arctic regions he discovered.

On May 13, 1596, the Amsterdam merchants fitted out two ships, and appointed Barentz leader of the expedition. Sailing this time in a still more northerly direction, the Dutchmen were the first of mankind to sight the largest known uninhabited region of the earth—Spitzbergen. They mistook it for a part of Greenland, and, after coasting round the western and northern shores, were stopped by the ice-pack. Thereupon Barentz turned his ship towards Novaya Zemlya, send ng the other vessel back to Holland.

Now began the great adventure of Polar exploration. On reaching Ice Haven, on August 20, 1596, just as the heavy pack-ice was drifting in, the ship was crushed between the floating masses, and fixed for the winter by the edge of the wild, bleak Arctic island.

There were seventeen stout-hearted Dutchmen on board, and to them fell the tragic honour of being the first Europeans to face the black and terrible Polar winter. Fortunately, they found a large supply of driftwood, and with this, and with planks taken from the poop and forecastle, they built a house on shore, and into it removed all their provisions and valuables. Cheerfully they went to work. They made a bath out of a wine-cask, they fixed a chimney in the centre of the room, hung up a Dutch clock that struck the hours, and made rows of beds along the walls. Through the skill, knowledge, and foresight with which Barentz directed their labours most of them survived their long, strange, and unexpected siege.

Soon the house disappeared beneath the snow, and a tunnel had to be made to get out. Bears mounted the roof, and tried to tear up the planking, but the sailors climbed up the chimney and fought them off. The men went out with snares, in between the snow tempests, and trapped blue foxes, and used the fur for garments and the flesh for food. Even in the house it was so cold that the ice was two fingers deep on the walls and floor and in the sleeping-cots. Barentz suffered greatly and became very ill.

He waited till June 13, 1597, when the sea was clear of ice, and then, abandoning the still imprisoned ship, he gave orders for the crew to take to the two open boats. He was so weak that he had to be carried from the house to the boat, and soon afterwards, on June 30, 1597, he died, and, like Franklin, found a grave in the midst of his discoveries.

The men landed at Lapland towards the close of August, and were picked up by a Dutch vessel. Two hundred and seventy-four years afterwards, on May 16, 1871, an explorer of the Pole rounded the north-east point of Novaya Zemlya, and saw a house standing in Ice Haven. He entered; the room was just as Barentz had left it. Even the clock was in its old place.

Subsequently Mr. Charles Gardiner visited Ice Haven, and found in the hut a flask containing a paper written by Barentz, the only known piece of his writing. The paper, with other remains, was presented to the Dutch Government by the discoverer.

SIR JOHN BARROW

From a Thatched Cottage to the Admiralty

Sir John Barrow was the son of a cottager at Dragley Beck, near Ulverston, in Lancashire. Within view of the little thatched cottage where he was born, in 1764, stands a high tower on a cliff above the sea. It was erected in honour of the cottager's son, a man who did more to advance geographical discovery than anyone of his period. His personal achievements were important, but not magnificent. He owes much of his fame to the help and direction which he gave to the leaders of Arctic expeditions.

SIR JOHN BARROW

He was taught at the grammar school of Ulverston, where five or six of the upper boys had subscribed for the purchase of a celestial globe and a star-map. Barrow greatly profited by this happy event, for astronomy became his passion; and while he was at school he never let a clear, star-light night pass without studying the constellations. Pursuing his hobby, he took up the science of mathematics, and at an early age became remarkably proficient in it; and, still in search of the arts connected with the study of his beloved stars, he induced a midshipman to teach him what he knew of navigation in return for lessons in advanced mathematics.

His parents wished him to enter the Church, but the lad craved for a life of adventure. Being poor, the earning of money was his first object, and at the age of fourteen he accepted a three years' engagement as timekeeper in a Liverpool ironfoundry. He must have been an uncommonly able boy, for in the last year of his engagement his master offered him a partnership. But Barrow was seventeen years of age, and thirsting for adventure; and, an opportunity offering, he went off to Greenland in a whaling-boat, and learnt the practical side of navigation while chasing and harpooning whales.

On his return he found that the iron-master was dead, and he had to seek some new means of livelihood. He was offered various positions as a sailor, as an estate manager in the West Indies, and as a mathematical assistant at a Greenwich school. He chose the teaching of mathematics, with a view to improving his own knowledge of this indispensable study. Three years were spent by him at Greenwich, and then came his great opportunity for seeing the world. Lord Macartney was going on an embassy to China, and Barrow obtained a position on his staff. So well did he profit by his stay in the East that the English Government twice afterwards sought his advice with regard to our affairs with China. In 1797 he accompanied Lord Macartney as private secretary to the Cape of Good Hope; and he studied botany at Kew Gardens in order to qualify as a scientific land explorer.

On arriving at Cape Town, he was sent by Lord Macartney into the interior on a double mission. He had to reconcile the Boers and Kaffirs, and explore and draw a map of the colony. In pursuit of these objects Barrow traversed every part of the country, covering 500 miles on foot and an equal distance on horseback, never, except for a few nights, sleeping under a roof. He was then appointed auditor-general of public accounts, married, and settled in a house looking on Table Mountain. But after spending three years as a colonist he left the Cape in 1802, when the English gave up the country by the Treaty of Amiens. He returned to London, and was made Second Secretary of the Admiralty, and this post he occupied, with a slight break, for forty years.

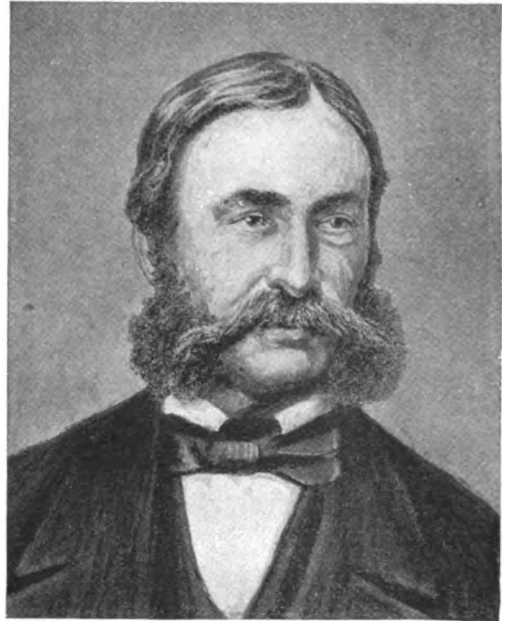
He began making plans for Polar explorations in 1817, and being in a position of great influence he was able to initiate some of the most famous expeditions in the nineteenth century. He also founded the Geographical Society in 1830, and his friend and admirer King William IV. gave him a baronetcy. He died on November 23, 1848, in the eighty-fifth year of his age. Around the North Polar region, Barrow Strait, Cape Barrow, and Point Barrow keep his name in perpetual remembrance.

HEINRICH BARTH
First Explorer of North Central Africa

Heinrich Barth, the greatest of North African explorers, was the son of a well-to-do merchant of Hamburg, and was born there on February 16, 1821. Unlike most explorers in their youth, he had no love of adventure, but only a curious passion for geography. At the age of nineteen he set out on a voyage to the Mediterranean to study its geography, and completed his study of the inland sea some years later by coasting from Morocco to Syria, and going on to Turkey by the isles of Greece. He travelled in 1845 from Tangier to the Nile, traversing the whole of North Africa; and so, when the British Government was fitting out the Richardson expedition for the exploration of the Sahara and the Sudan, the young German geographer was offered the position of assistant, which he accepted with enthusiasm. With him went a young German geologist, Dr. Overweg, and they met Mr. James Richardson at Tripoli, and from thence set out for the desert on April 2, 1850.

The principal aim of the British expedition was the abolition of the slave trade in the Niger country and the establishment of commercial relations with the natives. But how Lord Palmerston, the sender of the expedition, thought that three men could interfere with the slave trade, upheld by all the powerful chiefs of a vast tract of country, is not easily explained.

The explorers attained the unknown and dreaded region of Air, where their caravan was continually attacked and besieged, and at last ambushed. But the white men were able to buy themselves off with a ransom. They then put themselves under the protection of a Sudanese chief, and by paying him for his services were safely escorted to the edge of a more civilised region between Lake Chad and the upper bend of the Niger. Here the three white men agreed to part, and see what each could do alone, as they had lost most of their stores in their struggles with the desert robbers. Richardson set out direct for Lake Chad, Overweg started for Tausamaua, and Barth travelled to Kano and the Empire of Bornu.

Barth had to sell all he possessed to pay his way, and an attack of fever added to his difficulties. After a year's work of exploration he was quite destitute, but he pressed on to join his companions at Kuka town on the edge of Lake Chad; and on his way he learnt from a native that Richardson had died of fever. Barth reached Kuka in hopeless poverty, but

HEINRICH BARTH

the Sultan of Bornu befriended him; and, on March 7, 1851, Overweg rejoined him after an adventurous exploration to Sokoto. The two white men again separated, Barth exploring the immense forests hundreds of miles to the south; he reached the Benue river, and visited Yola, the capital of Adamawa. On September, 1852, Overweg, whose health had been undermined by the wet, hot climate, died, and Barth alone remained to carry out the enterprise of which he had at first been only an assistant. His courage and his robust constitution enabled him, amid many dangers, to accomplish his difficult task.

The British Government forwarded new supplies to him at Kuka, and he left Lake Chad on November 25, 1852, reached

Sokoto, and attained Timbuktu on September 7, 1853. News of his death reached Europe, and one of his countrymen—Vogel—was sent by the British Government in search of him. Vogel arrived at Kuka on December, 1853, and learnt that Barth had just left Timbuktu after a stay of nearly twelve months. Another year passed before Barth met Vogel, who was the first European he had seen for more than two years. The famous explorer spent the winter at Kuka, and arrived in Europe in September, 1855, after an absence of nearly six years. The series of explorations which he brought to a successful conclusion were unsurpassed by any during the busy nineteenth century. He made known to the civilised world the whole of a vast region which, even to Arab merchants, was more mysterious than any other part of Africa. His career was one of extraordinary adventure, and it was often by miraculous good fortune that he escaped from death at the hands of the natives. Even Vogel, who was sent out to help him, never returned, for he was put to death by an African chief. Barth's health, however, was greatly weakened by fever, want of food, and hardship, and he died at the age of forty-four at Berlin on November 25, 1865.

VITUS BEHRING

Discoverer of the Passage between Asia and America

Vitus Behring was born in 1680, at Horsens, in Denmark. He entered the service of Peter the Great when that reorganiser of Russia built his navy, and, distinguishing himself by his bravery and skill in the wars with Sweden, was promoted to the position of commodore. In the last year of his eventful life, Peter planned a geographical expedition with a view to extending the dominions of the Russian Empire. He desired that the whole northern coast of Siberia should be explored by sea, and that it should be ascertained whether Asia was separated from America by a strait. Two ships were to sail from Archangel by the North-East Passage, and two vessels to be built on the furthest point of Siberia for the exploration of the Polar Sea. A few days before his death he gave his final instructions to Behring, whom he appointed to lead the second expedition.

Behring left St. Petersburg on February 14, 1725, to carry out the orders of the dead Emperor. But the overland journey across Siberia, the accumulation of supplies, and the construction of a vessel at the remote port of Okhotsk, involved innumerable delays. It was more than two years before the newly built ship was able to sail the Sea of Kamschatka, carrying workmen and supplies for the building of the second ship. Finally, the vessel was made and launched, and on July 24, 1725, Behring set out, after three years and four months' preparation, for a voyage that lasted only seven weeks. He merely examined the coast for some distance northward, and partly ascertained the existence of a strait between Asia and America.

He returned to St. Petersburg, and, after another vain attempt at exploration, two new ships were built for him, with which, on June, 1741, he sailed on his last and tragically successful voyage of exploration. He reached the American coast on July 29, discovered the magnificent peak of Mount St. Elias, and explored the Aleutian Islands. Sickness broke out among the crew, and the commodore himself was attacked by it. At last only a third of the men were capable of work, and, while still exploring the islands along the American coast, Behring encountered a violent storm, lasting for seventeen days, and his ship stranded on a sand-shoal and broke up. Fortunately, the whole party was able to reach the island, now called after Behring; and, still more fortunately, the remains of the ship were thrown up by the sea within their reach, so that out of the wrecked timbers the men were able to build a boat during the following spring.

There was not a tree on the island, but they managed to make huts out of the driftwood. It was bitterly cold, for the wreck took place in November. Behring was very ill, and had to be carried on shore, and placed in a cavern dug in the side of a sand-hill. Here he was almost buried alive, for the sand kept rolling down continually, but he begged his men not to remove it, as it kept him warm. In this miserable condition he died, on December 19, 1741. It was scurvy that killed him; and as most of the crew was suffering from it, they were anxious to obtain the fresh animal food that would help them to recover. So they attacked the sea otters that swarmed on the island, and by eating the flesh of these creatures the starving, ill-clad men were able to fight against their fate. Many of them died, but forty-five escaped to Kamschatka in a little boat they built out of their wrecked ship.

CHARLES TILSTONE BEKE

The Man Who Mapped Out Abyssinia

Charles Tilstone Beke, the explorer of Abyssinia, was the son of a London merchant. He was born on October 10, 1800, at Stepney, then a charming suburb of London. He was educated at Hackney, and at twenty accepted a commercial appointment that took him to Genoa and Naples. Then, tiring of business, he entered at Lincoln's Inn, with a view to studying the law, but spent most of his time on geography and the origins of language.

His great learning was first appreciated in Germany, and in 1837 he was able to combine the pursuit of knowledge with the duties of a British consul at Leipzig. He studied especially the languages and customs of the East, and in 1840 set forth on his first exploration into Abyssinia, with the aim of opening up commerce with that country, and then proceeding to the discovery of the sources of the Nile. Abyssinia, at the time, was one of the most ancient, most remarkable, yet least-known of kingdoms. Beke mapped over seventy thousand square miles of the country, and recorded the vocabularies of fourteen languages. He crossed the eastern edge of the high tableland of Eastern Africa at points more than 400 miles apart, and found the watershed of the Nile and the rivers of the Indian Ocean. He was the first man to make known the physical formation of Abyssinia and Eastern Africa, and, though he did not discover the source of the Nile in the Abyssinian mountains, he pointed out the way to Speke, by showing the direction of the Nile basin.

GIOVANNI BATTISTA BELZONI

Beke again visited Abyssinia in 1865, to obtain the release of Captain Cameron and a number of other British subjects who had been wrongfully imprisoned by King Theodore. The masterful and tactful explorer was able, single-handed, to get the king to release the captives ; but when the king again imprisoned and ill-treated the British subjects he had set free, the English Government sent out a military expedition. Beke furnished maps and information to the army of rescue, and thus averted many dangers of the expedition, and saved many lives. King Theodore was defeated, and his fortress city captured in a campaign of remarkable rapidity, owing largely to the exploring work done by Beke.

In December, 1873, Beke went out to the Red Sea in search of the true Mount Sinai. He proved that a mountain in Arabia, called by the natives Barghir, was the historic height of Biblical tradition. The explorer returned to England in March, 1874, and died on July 31 of the same year. His work, entitled "Discoveries of Sinai in Arabia and of Midian," was published by his wife after his death.

GIOVANNI BATTISTA BELZONI

Revealer of Ancient Egypt

Giovanni Battista Belzoni was a novice in a monastery in Rome when, in the course of Napoleon's apparently irresistible career, a conquering army of Republicans occupied the city in 1798. Belzoni left the shadow of the cloisters, and looked around for a means of livelihood. The son of a poor barber of Padua, and born there in 1778, he had no one to turn to, but happily he was cast in a magnificent mould. He stood 6 feet 7 inches, and his strength was enormous. Winning a few pence by feats of strength at a country fair, he set up as a strong man, and in 1800 travelled to Holland, showing off his powers and his muscles, and displaying models of hydraulic machines. He toured through the United Kingdom, and crossed over to Spain and Portugal, where he played the part of Samson in a wordless drama. With the money thus gained he reached Malta, and then went on to Egypt.

Here he was commissioned by Mehemet Ali, the famous Viceroy of Egypt, to construct a hydraulic machine for raising water from the Nile. Belzoni, who was an expert in this branch of engineering, succeeded with his machine, but the fickle ruler lost interest in the undertaking. Belzoni quickly found another means of existence. He became a collector of Egyptian antiquities on behalf of the British Museum. Among the treasures he obtained for the English nation was the colossal bust of the so-called "Young Memnon," and the splendid sarcophagus from the tomb of Seti I., both of which are now in London. His greatest work was the exploration of the second pyramid of Gizeh. His discoveries made his name famous throughout Europe, and when he returned to Padua his native town feasted him and struck a medal in his honour.

Belzoni described his discoveries in a book written in English, and opened a popular exhibition of antiquities in London.

In October, 1823, he set out, at the head of an expedition, up the Benin River, with the aim of reaching Timbuktu, but was struck down with dysentery. He begged to be taken back to Gato, and there he expired on December 3, 1823.

JAMES BRUCE

Discoverer of the Source of the Blue Nile

James Bruce, "the Abyssinian," was born on December 14, 1730, at Kinnaird House, in Stirlingshire. He studied at Harrow and Edinburgh University, and grew into a big, masterful man with a genius for self-assertion. At twenty-four he set up as a wine merchant in London. But Bruce was a man made for a larger life, and with an unusual sense of humour the Government sent him out in 1763 as English consul at Algiers, on the pasha of that town complaining that the present consul was a man with a very obstinate nature. As the pasha was a ruffian with a vicious temper, the position of foreign envoy in Africa was more dangerous than pleasant, but Bruce learnt to be tactful as well as firm; and even when the French consul was loaded with chains for hesitating to obey the pasha, Bruce had the courage to interfere and attempt to check the savagery of the native governor. He stood like a man to his post, devoting every spare moment to the study of Arabic, and the geography of Egypt and Aybssinia.

Resigning his post at last in 1765, he travelled eastward by land to Tripoli, and, taking ship from Ptolemeta, was wrecked on the same coast, and suffered great hardships. It was three years before he arrived at Cairo. Here, by means of a dose of green tea, he managed to cure the leading bey of a stomach-ache, and as a reward he was given letters of recommendation to all the authorities down the long road to Abyssinia. Bruce sailed up the Nile and met an Arab chieftain, "the Tiger," who dominated the region round Kosseir, on the Red Sea. The royal "tiger" was also troubled with internal pains, and Bruce happily managed to relieve him, and received the good advice to turn back down the river and strike out to the Red Sea,

JAMES BRUCE

and sail from there to Massowah, the sea-gate to Abyssinia. This the Scotsman did. By doctoring the nephew of the governor, he saved himself from death, and then struck out over a mountain and passed from the Arabian territory into Abyssinia. His boots were worn out and his feet bleeding when he met a party of Moors and bought a horse from them, on which he rode into the city of Adowa.

His fame as a healer had gone before him, and he was courteously entertained by an officer of the port and sent on to Gondar, the capital city, with a recommendation to the mother-in-law of the kingly usurper of the throne. Some of the royal children

were suffering from smallpox. Bruce tended them in a common-sense manner, using no medicine, but nursing them carefully, and brought them safely out of danger. The king was so pleased that he made the explorer an officer of the royal household, and gave him the command of a troop of horse. Bruce was allowed to go where he liked, with four men carrying his quadrant, two others his timekeeper and telescopes, and a body of soldiers to protect him.

Unhappily Bruce rode daringly one day into the camp of a chief who was fighting for the rightful heir to the throne. He wanted to get the chieftainship of a village where he hoped to find the source of the Nile. The royalist had heard of Bruce's healing power and would not let him go. There was a quarrel; Bruce had a temper equal to his size, and, careless of death, he stormed at the chief until blood streamed from his nose. Simply by the torrent of his passion he quelled the Abyssinian chief and obtained from him the village he wanted. There on November 14, 1770, he found, on a green hillock, the two fountains of the Nile. Though he did not know it at the time, he had only reached the source of the Blue Nile. Ninety years was to pass before another British explorer traced the White Nile to its source in Central Africa.

Bruce struck out into the Nubian Desert instead of returning to the Red Sea. There was a king of Nubia in those days living at Sennaar. Bruce doctored some of his wives, and followed the Nile to a hamlet close to the site of the Khartum of our time. At Berber, unfortunately, he led his caravan across the Nubian Desert instead of keeping to the longer but safer track by the banks of the Nile. When he reached Assuan he was dying of thirst and unable to walk. His valuable drawings and instruments were left in the sands. But the sight of water-birds that he had seen before he regained the Nile kept Bruce hopeful. Some of his men were blind, the camels were too exhausted to walk, and Bruce had to be helped forward by his servants. But on November 29, more than two months after leaving Sennaar, the palm-trees of Assuan were seen, and on December 17, 1770, Bruce arrived at Cairo, "sufficiently cured," as he remarked, "of any more quixotic undertakings." When he published his book on Abyssinian travel, his curious account of the manners of the Abyssinians led Dr. Johnson and many other persons to regard his tales as fabrications, but modern travellers have confirmed the accuracy of his observations. Bruce died at Kinnaird, on April 27, 1794, owing to a fall downstairs—a singular end to a life of adventure.

THE TOWN OF ADOWA, ABYSSINIA, AT THE TIME OF JAMES BRUCE'S VISIT

SCENES IN THE TRAVELS OF SIR JAMES BRUCE

THE VILLAGE OF MASSOWAH, ON THE RED SEA

THE MOUNTAINS OF TIGRE, SEEN FROM DIXAN, ABYSSINIA

FRANCIS BACON AS LORD CHANCELLOR, FROM THE PAINTING BY VAN SOMERS
This photograph of the portrait in the National Portrait Gallery is by Emery Walker

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THINKERS

ANAXAGORAS

The Greek Philosopher who Conceived the Thought of God

ANAXAGORAS, one of the profoundest of the ancient philosophers, was born at Clazomenæ, near Smyrna, in or about the year 500 B.C. He inherited great wealth, but a greater passion for truth, to which he devoted his life, ignoring the opportunities of politics. The intellectual environment of Clazomenæ stifled him, and he yearned for Athens, in the words of George Henry Lewes, " as all energy longs for a fitting theatre on which to play its part."

The Age of Pericles, unexampled before or since in the history of mankind, was at hand. The young Pericles, indeed, and Euripides, and, according to some accounts, Socrates himself, soon came to be ranked among the pupils of Anaxagoras in Athens.

Devoted as he was to the universal problems which appealed to him as to those like him in all ages, the wealthy young thinker neglected his affairs until at last he found himself penniless, whereupon he exclaimed, " To Philosophy I owe my worldly ruin, and my soul's prosperity." As a teacher he soon gained fame, and incurred the jealousy of unworthy rivals, who, taking the great name of Religion in vain, then, as in so many other times and places, brought accusations of blasphemy against the thinker whom they could not and would not understand in his attempts to enlarge men's notions of Deity. Arraigned, tried, and condemned to death, he escaped with his life, thanks to the intervention of the great statesman Pericles, who had sat at his feet.

He was sentenced to life-long banishment, and went to Lampsacus, where he spent the rest of his life. In Athens he had taught the Truth as he saw it for some thirty years, but this was his reward, and he may be forgiven for his proud remark, " Not I have lost the Athenians, but the Athenians me."

Many difficulties face the scholars who seek to state, in our language and terms, the beliefs and teaching of so remote a thinker, none the less because, like many another, even of such high rank, Anaxagoras did not necessarily teach one and the same consistent doctrine throughout his life.

Yet, though we cannot be sure as to many things, the main tenets of this pioneer may be defined clearly enough. He was, in the first place, a man of science in his belief that many physical phenomena, vulgarly and ecclesiastically attributed to the caprice of the " gods," were really produced by natural causes. In this and in other notable respects he was certainly a follower and expounder of his illustrious predecessor, Thales. We can readily understand that the cry of atheism might be raised against a teacher who found natural causes for such phenomena as the heat and light of the sun, and who could predict eclipses, as against the view that such forces and events were immediately directed by the " gods." Just similarly, some two thousand years later, Newton was accused of atheism because he explained the motions of the heavenly bodies by gravitation.

Anaxagoras recognised the doings and the material structure of the physical world to depend upon the combination and interaction of elementary and simple units which we may accurately enough call atoms, so long as we do not include in that term all the ideas of modern chemistry. The question that remained, above and below all, for him to answer was the *cause* of these combinations and interactions, including those of which living beings are the most subtle and astonishing examples.

His answer was given in his sublime and noble doctrine of a universal mind, or Nous, to use his own term, which is the Prime Mover of the universe. As ever and ever again in the history of thought, we observe that the so-called atheist is often he who has ideas of God too great for small minds to hold. Anaxagoras considered the claims of Fate and of Chance as the masters

of the world. In the first he saw a mere name for what we do not understand, putting off our questioning and explaining nothing. In chance, profound anticipator of later thought as he was, he recognised merely the action of law under forms which our reason cannot suffice to define. Only Intelligence was therefore left as the possible disposer and mover of the world—Mind infinite, eternal, universal, which, to quote the thinker's own words, "knows and arranges all things that ought to be, that were, that are and that will be."

It is not possible to find earlier in the history of thought so complete and sublime a conception of Deity as this philosopher framed; and if we call Theology a science, as indeed it is, then Anaxagoras may well be named its father.

He died at Lampsacus in 428 B.C., thinking to the end; and, when asked to name a memorial for himself, replied from his death-bed that his death-day should be a holiday in the schools of the city, a request which was complied with for centuries. And over his grave was written this epitaph:

> This tomb great Anaxagoras confines,
> Whose mind explained the heavenly paths of Truth.

ANAXIMANDER
The Man who Took a Great Step Towards the Truth

Anaximander, one of the earliest of natural philosophers, was born at Miletus in 611 or 610 B.C., and may be ranked as the successor of Thales. It is principally to Aristotle that we owe our knowledge of him and his achievements, which must have been very great in certain directions. His observations of the heavens enabled him to construct what was presumably the first sun-dial, and his study of the surface of the earth led him to sketch a kind of map, so that he may be called the first cartographer. He is said also to have declared that the moon shines by light derived from the sun; and he is, perhaps, above all, justly famous for his assertion of the belief that the earth was cylindrical in shape. This colossal assertion, so great a step towards the truth as we know it, was first conceived, so far as any record goes, in the brilliant mind of this student.

He was, however, more than an astronomer. His devotion to mathematics and to mathematical ideas led him on to speculate as to the ultimate nature and origin of things. His conclusion was that things have their origin in the Infinite, but it is clear that his conception of the Infinite did not comprise the idea of mind, which was for him only a terrestrial and ephemeral product, as for materialists in all times. To their number, in polar contrast to Anaxagoras, this early philosopher belongs. He is said to have died about the year 547 B.C.

THOMAS AQUINAS
The Angelic Doctor of the Darkest Centuries

Thomas Aquinas, the greatest figure of mediæval Scholasticism, was born in or about 1227, and belonged to the illustrious family of the Counts of Aquino, a town between Rome and Naples. He was a born "intellectual" and student. Six years' study at the University of Naples were enough to make him a fervent follower of learning where it was best, as he thought, to be found. Thus, at the early age of sixteen, and against the earnest wishes of his father, the Count, and his mother, he became a Dominican.

This was perhaps the best fate that could have befallen him in that age, though we may well wonder what course his mind would have taken had he been born in the age of Pericles or Augustus or Darwin. The most famous thinker of the time, Albertus Magnus, became the teacher of the young Thomas of Aquino, who learnt with ardour and ease all that was set before him. From the beginning to the end of his comparatively short life he was a tremendous worker, and has left behind him not merely an influence which dominated the thought of Western Europe for centuries, but also an astonishing quantity of actual writing, much of it original, and much of it of the nature of commentaries, which display an insatiable and apparently untiring studiousness.

To this he was born, and nothing could stop him. The parental opposition which had kept him a prisoner in his father's castle for two years was not enough to check so intense a love of knowledge, even in a man whose gentleness of disposition, consistent courtesy, and piety were ere long to earn for him the title of the "Angelic Doctor," by which he has been ever after known.

Any attempt to understand or appreciate this remarkable man must be based on a clear understanding of the time and circumstances of his life. In order to know him we should know the thirteenth century. Europe was still in the "thousand years of darkness." All the learning that was recognised was in the hands of the Church, which Aquinas ardently loved and believed in. But with this love and faith of his, and acting throughout all the years of his initiation into Roman Catholicism, he had also one of the most acute, eager, and profound

intellects of which we have any record. Any form and order of knowledge was grist to his mill; but all the while his faith in what Holy Church taught made it necessary for him, by some means or other, to reconcile the findings of science with her dogmas. In so far as this task was valuable at all, Aquinas was, perhaps, of all men of all times the best qualified for the purpose.

Though he was himself ignorant of Greek, he obtained access to Aristotle in Latin, and became the great introducer of the "master of them that know" to the mediæval and modern world. He sought to include all Aristotle's findings in a complete scheme of knowledge of human and divine things; and though nothing but first-hand and prolonged study can reveal to us of today the full nature of Aquinas's task, we may dimly imagine what it meant to accept the independent "pagan" thinker, logician, naturalist, and moralist, and at the same time to bring him into harmony with Roman Catholicism. The result of this attempt was the amazing product of the human mind which is called Scholasticism, and of those who laboured at its making Thomas Aquinas is the acknowledged master and centre. At this very hour the influence of the schoolmen, and thus of Aquinas above all, is paramount in the system of Roman Catholic learning; and centuries had to pass before a fresh beginning could be made, within the Church or without it, in place of that monument of faithful but hopelessly misapplied ingenuity and intellect which we call Scholasticism.

It was the judgment of Huxley that Aquinas possessed the most powerful and subtle intellect of which we have record; and we have already seen with what assiduity its possessor used this masterful machine of his. Rapidity and confidence must have marked his logical processes, for he found time to make many journeys, and play a great part in the practical and political life of the Church in his time. Few men have enjoyed more honour and fame for their intellectual powers than this sweet-mannered man and stern logician; and successive centuries have only added to his reputation in the Church which he served so astonishingly well. Duns Scotus, the "Subtle Doctor," became the "Angelic Doctor's" great rival in the estimation of the Church; but the Thomists finally won the day against the Franciscan Scotists, and have remained as the Centre Party, so to say, in Roman Catholic thought ever since, with the Jesuits as their chief rivals.

The greatest work of Aquinas was his comprehensive treatise the "Summa Theologiæ," in which, after many preceding years of labour, he sought to summarise and state the whole of human knowledge in its due relation and proportion as part of Theology, or the Science of God, as that is understood by the Roman Catholic Church. His other great book was his "Sum of the Catholic Faith against the Gentiles," which is usually referred to by the last two words of its original title, as the "Contra Gentiles." Of this a quite superb translation in English was published a few years ago by Father Rickaby, of Oxford, with voluminous and invaluable notes. Students in this country, and not least men of science, should be very grateful to this distinguished scholar for so laborious and valuable a piece of work.

The spectacle which it presents to the student of contemporary knowledge is unique. Aquinas believed *both* in revelation and reason. What was "de fide," part of the faith, must be believed, though reason could not prove it, and though it might be incomprehensible or opposed to reason. The "mysteries" of dogma were true for him even when they contradicted each other or themselves. Yet at the same time he believed in reason, in logic, in evidence, in the laws of sound inference from premises, and was indeed the appointed interpreter to the Western world of the great master of logic and scientific observation, Aristotle himself.

Hence the colossal difficulty of his task. Some fragments of what is commonly meant by science had been preserved by the Arabs from the ruins of the Greek civilisation, and some of the Arabian thinkers and students had made discoveries of their own. All the science then existing was for Aquinas. He welcomed and delighted in it. But he was not like ninety-nine people out of a hundred, who find no clashing between the dogmas of their religion and the teachings of science, simply because their minds are built up in idea-tight compartments, and, as Faraday said of himself, they keep their religion in one pocket and their science in another.

For so rarely endowed an intellect as Aquinas, it was necessary to harmonise and unify all that revelation had vouchsafed to or through the Church, and all that rational processes had discovered. He had to build up a simple, coherent, and consistent system of thought based on two foundations so unthinkably diverse as Aristotle and Roman Catholicism as it then was. We

need scarcely be surprised that every help to be derived from intellectual subtlety, and even from the confusions of language, was necessary for such a task. But we err greatly, and do the "Angelic Doctor" little justice, if we accuse him of any personal dishonesty of mind or intention. He never questioned the truth of revelation or reason, he knew that all truth is one, and every device which he employed was the inevitable consequence of these premises. He belonged to the small but illustrious company of honest and powerful thinkers, and his name must be held in honour today, even by those who almost vainly seek for a few grains of value among the vast ruins of the scholastic philosophy.

Living for learning, Aquinas consistently refused ecclesiastical preferment. He had no time to be an archbishop or an abbot, though such offices were offered him. But he was required none the less in the councils of the Church. On his way to such a council, in the earliest days of the year 1274, and already ill, he was struck down so that he could not continue his journey. Thus, on the route from Naples to Lyons, he died on March 7, 1274. Few men have been the possessors of greater powers, or have used powers more faithfully.

ARISTOTLE

The Master-Thinker of the Ancient World

Aristotle, who sought to unify all knowledge, and was "the most profound and comprehensive thinker of the pre-Christian world," was born in the year 384 B.C. at Stageira, in Macedonia, the son of a physician. As a young man, he was doubtless expected to follow the family profession of doctor, and had prospects of success, for his father was medical adviser to both the grandfather and the father of Alexander the Great. But one branch of knowledge was too narrow for Aristotle. Like Bacon, he took all knowledge for his province, till he became, as Dante said, "the master of those who know."

His life was varied and romantic for a man of thought. In his eighteenth year (367 B.C.) he made his way to Athens as a student, presently became a frequenter of Plato's academy, and so continued, more or less, till middle life, though he also set up a school of his own for oratory—a valued part of Athenian education. After Plato's death, in 347 B.C., he left Athens and lived for three years in the town of Atarneus, in Asia Minor, where the ruler, Hermeias, was a pupil and friend from Athens. After the death of Hermeias, Aristotle married a relative of his friend, and lived for two years in the island town of Mitylene. Thence he was invited by Philip of Macedonia to undertake the education of his young son Alexander, and for three years Aristotle was the preceptor of the would-be conqueror of the world. Afterwards Alexander declared that he loved and revered Aristotle as much as he loved and revered his own father, for "he was indebted to the one for life, and to the other for living well."

When Alexander set out on his career of conquest, Aristotle, who did not approve of the enterprise, returned to Athens, but he no doubt remained there a cordial supporter of Macedonian interests. During the next twelve years Aristotle did the work which, as has been said, gave him command of the thought of the world for a thousand years. Establishing a school called the Lyceum in "The Walk," near the temple of Apollo Lyceius, he developed his philosophy for the advantage of his followers, until practically the whole of the then known knowledge of the world began to systematise itself in his mind, and he conceived the idea of producing a complete cyclopædia of philosophy, on lines that we should now call scientific. Large sections of the work were planned, and some were fully thought out and filled in, in writing—as, for example, a treatise on logic that was entirely original, and has never been superseded. Other sections were left as bare outlines, and some as magnificent fragments, when, on the death of Alexander, jealousy began to conspire against the life of the great teacher, as it had conspired before against the life of Socrates, and, as a precaution, Aristotle retired to Chalcis in 322. His health had been impaired for some time, and in the same year, at the age of sixty-two, he died.

The perpetuation of his influence is one of the great romances in the history of thought. His followers were not capable of expanding, or perhaps even of interpreting, the system of thought he had striven to bring into being, though they continued to discuss fragments from it, and wrote sectional treatises which, later, were accepted as his. Other schools of thought arose—the Stoics and Epicureans—and drew away attention by their controversies, so that his influence waned in the city where he had done his life's work, but had always been a stranger. Then his writings, bequeathed to his chief disciple, were handed on to that disciple's literary heir, who carried away the manuscripts to Asia Minor and carefully hid them from a local king, who was forming

a library by the kingly process of "requisitioning." It was not till nearly two hundred years later that these writings were returned to Athens. There they were seized, carried to Rome, and carefully collated and edited.

Meantime, spurious works had been circulated in the name of Aristotle, and the scope of his work, the true significance of his thought, and even the qualities of his style, were misjudged by the writers of Rome in his day of literary predominance. And later, when what was supposed to be Aristotle's philosophy was accepted largely by the mediæval schoolmen, and was made the basis of much of their teaching, it was a version taken not from his original writings, but accepted from the Arabic versions of Avicenna and Averrhoes, which had been translated from Greek into Syriac, and then into Latin, with accretions of Oriental thought by the way. The fact is that during the dark night of fettered thought, before the great revival of learning and the outburst of freedom which followed, men were not ready to understand the writings of a fearless inquirer like Aristotle, who was not bound by precedent, but wished "to investigate all that can be known, and to express what he found exactly and exhaustively." And even now some hasten to misjudge him, through failing to realise the conditions under which he lived and thought.

We must be content to accept such facts as that Aristotle's philosophy was only intended to refer to a twentieth of the people around him; that it was a flattery of 20,000 superior persons living on the labours of 400,000 slaves who could have no participation in liberty or in property; that it asserted the impossibility of "caring for the things of virtue while living the life of the artisan or the slave;" that it excluded the mechanical and utilitarian arts as involving work too servile for the attention of a free man; and regarded women as essentially inferior to man, and incapable of sharing his intellectual privileges.

We may wonder that such a great thinker could have suffered these limitations in his deliberate phisolophy, but it is a far greater wonder that one living in an age which accepted these ideas as matters of course could have mapped out the world of mind so completely, and be hailed as "the father of nearly all the modern sciences." The divisions of learning in our Universities today are his divisions. In some of the sub-divisions he almost said the last word. The very language in which we express our abstract ideas is adopted from his phraseology. Whether we speak of philosophy or physics, of metaphysics or biology, of physiology or pschology, of ethics or logic, or economics, or politics, of poetry, or oratory, or the drama, or criticism, of natural history, or astronomy, of hygiene or education, or even the weather, he has been there before us, sometimes, it may be, with little knowledge, but always with keen analytical insight. Though he lived before the greatest physical laws of the universe were discovered, and before the mind of man knew true liberty, he has been described as "by common consent the best educated man of any age, with the greatest influence on subsequent times."

ARISTOTLE, THE MOST PROFOUND AND COMPREHENSIVE THINKER IN THE WORLD BEFORE CHRISTIANITY, INSTRUCTING A PUPIL IN ATHENS

ROGER ASCHAM

The Man who Humanised Teaching

Roger Ascham was the pioneer of all who have written in the English tongue about methods of education, and, within the range of education as it was conceived in his day, none has written more wisely. He was born at Kirby Wiske, near Thirsk, in 1515. As a boy he attracted the attention of a neighbouring magnate, Sir Anthony Wingfield, who educated him with his own sons, and sent him, at the age of fifteen, to Cambridge, where—such was his aptitude for the classical tongues—he took his degree and was made a fellow of his college before the close of his eighteenth year. Ascham's whole life afterwards was either that of a University don, or a man of learning acting as secretary in public or semi-public offices.

Notwithstanding his consistent Protestantism, he retained royal favour, employment, and modest pay through the later years of Henry VIII., through the reigns of Edward VI. and Mary, and until his death in the eleventh year of Elizabeth's reign, when the penurious queen declared that she would rather have lost ten thousand pounds than her tutor. In this academic and official career of thirty-five years, Ascham was a classical tutor at Cambridge, Greek reader for the University, university orator, tutor to the Lady Elizabeth (afterwards Queen), secretary to the English ambassador to the Emperor Charles V., secretary to Queen Mary, and private secretary and tutor to Queen Elizabeth.

His amusement was archery, and his first book, published in 1545, was on that exercise, and entitled "Toxophilus, the Schole of Shootinge." He dedicated it to Henry VIII., with the avowed object of securing enough money to enable him to pursue his studies in Italy, and the King responded by furnishing him with the very modest sufficiency of ten pounds a year. In the last years of his life, as the result of a conversation with Cecil, Ascham wrote, in English, his views of education. The book, incomplete at the time of his death—December 30, 1568—was published two years afterwards by his wife, Margaret, under the title "The Scholemaster." It at once secured, and has retained, the attention of the whole world of scholarship, and is one of the few serious English books that—like those of Locke and Herbert Spencer in later years—have kept a place in the literature of Europe. His "Letters," 295 in number, have also been published, and, besides their charm of style, are a mine of incidental information respecting the men and doings of his time.

Ascham's contributions to education are, first, his revolt from the harsh spirit that dragooned the young into learning. "In my opinion," he wrote, "Love is fitter than Fear, Gentleness better than Beating, to bring up a child rightly in learning . . . young children should be rather allured to learning than compelled . . . If ever the nature of man be given at any time more than other to receive goodness it is in innocency of young years."

Then, secondly, his method of teaching was as sensible as it was humane. Instead of making the scholar learn first the grammatical rules of Latin, without understanding, he insisted that the child should first be taught, "cheerfully and plainly the cause and matter of the letter," a Latin passage being construed into English by the master so as to be easily understood. It should then be parsed and the rules educed. Next, "the child must take a paper book, and sitting where no one shall prompt him translate his lesson into English. Then, pausing an hour at least, let the child translate his own English into Latin in another paper book." The master is then to "lay together" the child's Latin and the original Latin, and praise him and say "Here ye do well." Particularly Ascham insisted on writing as "the only thing that breedeth deep root," and on the exhaustive mastery of one or two books.

Dr. Johnson declared that Ascham's treatise contains "the best advice ever given for the study of languages." Of Ascham, the man, Professor Arber says he was a strong, plain Englishman, of generous heart, tolerant spirit, thorough scholarship, loved and honoured.

FRANCIS BACON

"The Wisest, Brightest, Meanest of Men"

Francis Bacon, afterwards Lord Verulam, Viscount St. Albans, was born in London, on January 22, 1561. His father, Sir Nicholas Bacon, was Queen Elizabeth's famous Lord Keeper of the Great Seal. His maternal grandfather had been the learned tutor of Edward VI., and his mother was herself of rare intellect, a scholar and an ardent follower of Calvin. Her elder sister married Lord Burghley, so that there are living men of political and philosophical note who are connected by blood with Francis Bacon. The boy was delicate and precocious, and is believed to have been assiduously taught and disciplined by his remarkable mother.

Entering the University of Cambridge, he there came to the conclusion that philosophy, as represented by the current Cambridge rendering of Aristotle, was fallacious and in need of radical reform. He entered Parliament, and thereafter his life, more markedly than that of any other of the great figures of history, is a double one, part of it being the record of political and civic advancement, intrigue, treachery, dishonesty, disgrace, and part of it being the record of a great thinker, endeavouring to frame a theory of knowledge, and a method, or *organum*, of research by which knowledge could be rapidly and surely advanced for the benefit of existing men and of all posterity.

ROGER ASCHAM AND HIS PUPIL, LADY JANE GREY
From the picture by J. C. Horsley, R.A.

This "wisest, brightest, meanest, of mankind" concerns us here in his capacity as a thinker. Yet, though it is impossible to trace any relation between his external and internal lives, it is necessary, very briefly, to recall the external circumstances of the man to whom we owe some of the greatest prose and most notable thinking in our language. The author of the noble essay on "Death," of the "Advancement of Learning," and of the "Novum Organum," a new instrument of knowledge, was also

an ambitious and none too scrupulous lawyer. Having trampled upon the heads of many friends on the way, he became Lord Chancellor, but was convicted of corruption, was sentenced to be imprisoned and banished from Parliament and the Court. This was in 1621, and Bacon still had five more years to live, during which he concerned himself wholly with the immeasurably worthier of the two interests to which his life had been devoted.

In 1620, one year before his viscounty and his fall, Bacon—who is often but wrongly called "Lord Bacon"—published his masterpiece, the "Novum Organum." His "Essays," written in English, are familiar to a far wider circle of readers as one of the classics of our prose literature, but the "Novum Organum" can now readily be obtained in English in cheap and good editions, is not a long work, and is remarkably easy to read, considering the nature of its subject matter.

A notable characteristic of this man's personality was his belief in himself. To him it was clear that previous thinkers and observers were, and had always been, wrong in their methods and whole course of procedure, with the rarest possible exceptions; and it was no less clear that to him had been left the task of stating the sound methods of discovering truth, and of setting men thereto, with such security that even their natural differences of capacity would be immaterial, for his method would "level men's wits," so that anyone who followed it could certainly, if somewhat laboriously, find out anything.

Before we look more closely at his teaching, let us note, however, that Bacon did not himself make any discoveries, or put his theory to the proof; that he was not acquainted at all thoroughly with the knowledge of his time, even rejecting the stupendous discovery of Copernicus that the earth goes round the sun; that he did not even acquaint himself with Harvey's discovery of the circulation of the blood; and that in these and many other ways he laid himself open to the remark of the immortal physiologist Harvey himself, that "the Lord Chancellor writes on science like a Lord Chancellor." Nay, we may add that subsequent students have not followed Bacon's method as he laid it down, and that the really valuable parts of it had, in fact, been employed by first-hand students of Nature ever since the dawn of science. But when all is said, as it must be said, against the vast pretensions of its author, and the uncritical praise of many of his commentators, the "Novum Organum" remains a landmark in the history of thought, and one of the greatest masterpieces in the literature of knowledge.

We live in a time, said Bacon, when true learning has become stifled by the arrogance of its professors, by a cloud of words and phrases, long destitute of any meaning they may ever have had, and when we need to get back to Nature herself at first-hand, if we are really to learn anything about her. Beyond a doubt, Bacon was right, and his book marks the definite and effective beginning of what we call modern science. A few years hence, in 1920, the lovers of knowledge throughout the world will undoubtedly combine to celebrate in some notable way the tercentenary of the "Novum Organum," with which what we now mean by science begins, or makes so fresh and great a re-beginning that, at any rate, everything has been different since.

The vice of philosophers, Bacon declared, was that they started from certain general propositions, and then proceeded to state therefrom the facts of the world, without troubling to look at the facts themselves. This method of the armchair philosopher, who evolves the details of the world out of his head with his eyes shut, may be called, said Bacon, the "anticipation of the mind," whereas the true and only useful method is "the interpretation of Nature." "Man," said he, "is the servant and interpreter of Nature," and directly he forgets this place and post of his, and starts to reason from his own notions, which is so easy and gratifying to his pride, he is sure to go wrong.

The mind will serve us well, if only we use it properly. But we allow it to worship the "idols of the mind," "certain idle dogmas," instead of the "ideas of the Divine mind—the real stamp and impression of created objects as they are found in Nature." The reader must go to Bacon himself for his celebrated and masterly definition and exposure of these idols, which beset every one of us today and every day, exactly as they beset Bacon nearly three centuries ago, or Aristotle two thousand years before him. As Bacon said, "The human understanding resembles not a dry light, but admits a tincture of the will and passions, which generate their own system accordingly, for man always believes more readily that which he prefers." And yet, though the preferred belief may have some kind of value for the individual, may serve his life, though it be false, yet the truth is what will really serve all mankind best. "Man can only govern Nature by

obeying her," said Bacon, and therefore he must find out what her laws are. To this end only one means avails, and that is the systematic, patient observation of facts, and then a process of inference or induction therefrom. Hence we call Bacon the father of the inductive or scientific method.

Though Bacon made no discoveries of his own, and though he underrated the importance of wisely framed hypotheses in the search for truth, he was a genuine researcher when time availed. Early in 1626 he exposed himself unduly to cold while making an experiment on the effect of snow upon the preservation of flesh. He has not told us how long the fowl which he stuffed with snow remained sweet, for he fell ill and died at Highgate, near London, on April 9, 1626. His bones lie in St. Michael's Church, St. Albans.

WALTER BAGEHOT
The Apostle of Evolution in Politics

Walter Bagehot, one of the freshest and most detached minds of the nineteenth century, who appealed by all he wrote to thinkers of his own and foreign lands, was born at Langport, in Somersetshire, February 3, 1826, the son of the general manager of a prosperous bank, and of its founder's niece. His education, begun at Bristol, was completed at University College, London, where he took a mathematical scholarship with his Bachelor's degree, in 1846, and the gold medal in Intellectual and Moral Philosophy with his Master's degree, in 1848. In connection with University College, Bagehot found some of his best and life-long friends, such as Richard Holt Hutton, of the "Spectator," and Arthur Hugh Clough. At first the intention of the young student was to join the Bar, and indeed, in 1852, he was "called," but he finally determined to continue his father's banking work, which he variegated with journalism of the higher kind, writing first for the reviews, and later for the "Economist," of which he was the editor from 1860 to his death, at Langport, March 24, 1877. He had married, in 1858, the daughter of the Rt. Hon. James Wilson, the founder and proprietor of the "Economist."

Bagehot's social position, and his life as a serious journalist, brought him into close touch with politics and business, while his personal taste found in literature a high delight. On each of these lines Bagehot gained lasting distinction as a writer. He was an original political economist, a lucid political thinker, the author of the most searching and illuminating book on the English Constitution, and the only work on City of London financial operations—his "Lombard Street"—which may be said to handle business while touching literature. But while he will long remain a classic in a department of writing otherwise surrendered to dulness, Bagehot will chiefly live through his extraordinarily stimulating criticism of literature and men, gathered by his friend and biographer, Richard Holt Hutton, into volume form from various publications, as literary and biographical studies. Nowhere else in English criticism is there any writing that flashes with such piercing insight. The fact is that, in a singular degree, Bagehot thought for himself. With a strong yet subtle mind, he also had vision, sudden, imaginative charm, and over all a play of humour, swift, keen, but not ill-natured. It was said of him as a conversationalist that he never answered a question without either making the questioner think or laugh, or both think and laugh; and the truth of that estimate can be surmised by every reader of his more discursive books.

As a youth Bagehot wrote letters from Paris during the days of the Third Napoleon's *coup d'état*, in which he rioted in satire while defending Napoleon's action, apparently to shock the staid readers of the "Inquirer" newspaper, but his genius shone even through this humorously malicious exuberance. But he quickly sobered to a sense of responsibility, and his "English Constitution" and "Economic Studies" have become text-books of university education, while his "Physics and Politics"—an application of evolution to social developments—has commanded the attention of thinkers throughout the world. The weakness of Bagehot's political work was that, while he had abundant imagination, he had little faith, particularly in the popular mind. He did not give sufficient credit to average worldly wisdom compared with the intellectual incisiveness which was his own possession.

As a man Bagehot had great charm, though he was somewhat intolerant of thinking that was feeble and confused; and the memoir by his friend Hutton that prefaces his collected work is one of the most sensitive and delicate pieces of biography in the English language. No original man was happier in his death, inasmuch as he left behind an admiring friend who could picture "a nature high-spirited, buoyant, subtle, speculative, in which the imaginative qualities were even more remarkable than the judgment, a gay, dashing humour, the

life of every conversation, and a visionary nature to which the commonest things seemed the most marvellous, and marvellous things most intrinsically probable."

ALEXANDER BAIN
The Modern Exponent of a Material Mind

Alexander Bain, the Scottish psychologist, was born on June 11, 1818, in Aberdeen, his father being a handloom weaver, who (to quote Bain's own words, in his "Autobiography") "was both expert and industrious," and "could earn considerably over a pound a week." The boy's home life was severe. His education began early, and he needed all the constancy of purpose and untiring energy which he inherited from his father—a father who worked at his loom fifteen hours a day, six days a week, to cope with the needs of his large family. The boy was taught religion by his father and others, of a type and in a manner which may have largely accounted for his subsequent mental attitude.

Young Bain early distinguished himself in the university of his native town, both in what we nowadays call psychology and in the physical sciences. Soon he began to write, becoming an ally and fellow-worker of John Stuart Mill, with whom he is definitely to be classed as a member of the "associationist" school of psychologists. In 1860 Bain became Professor of Logic in Aberdeen, having already published his two great books, "The Senses and the Intellect" and "The Emotions and the Will," in 1855 and 1859 respectively. His psychology was based entirely on physiology, and represents the furthest limits that could be reached on the lines of the school to which he belonged. But half a century later it seems to belong to a mode of thought we have far outgrown, though the work of the materialists was doubtless necessary in its time and place.

After a long life of incessant work, Bain died on September 18, 1903, not far from his birthplace. Had there been a crematorium in Aberdeen, he would have been cremated. He requested that no stone should be placed upon his grave; his books, he said, would be his monument.

SIR WILLIAM FLETCHER BARRETT
An Explorer of the Shadow-World

Sir Willam Fletcher Barrett was born on February 10, 1844. His father was a Congregational minister, who published, some sixty years ago, a popular work on geology which gained him the odium of a heretic. In his twentieth year young Barrett became assistant to Professor Tyndall at the Royal Institution, and there he remained for four years, seeing a great deal of Faraday, whom he describes as "one of the most beautiful characters I have ever met." From 1873 to 1910 Sir W. F. Barrett was Professor of Physics at the Royal College of Science in Dublin. As a physicist, Professor Barrett is known for his discovery of sensitive flames, which are affected by very faint sounds, and for the discovery of the recalescence, or sudden reglow, of certain metals when cooling from a white heat.

But his most important work has been connected with the scientific study of the most mysterious and important and neglected of psychical phenomena. As early as 1876 he read a paper on "Thought Transference" before the British Association, and in January, 1882, there was founded by Barrett and others the Society for Psychical Research, of which he became one of the first vice-presidents.

Professor Barrett has written largely, above all, on thought transference and on the curious facts of the "dowsing-rod," by which the "dowser" is said to be able to detect the presence of underground water. Early in 1912 was published his small volume on "Psychical Research," which has been very widely read, and he has since published a book on Swedenborg. As a trained and academic man of science, who became a pioneer in a neglected, despised, yet vitally important field of study, he has earned for himself a secure place in the history of knowledge.

JEREMY BENTHAM
The Hermit Prophet and Philosopher of Radicalism

Jeremy Bentham was born in Houndsditch on February 15, 1748. His father was a well-to-do solicitor. The precocity of the child led the father to invent eccentric methods of education; he was continually exhibited as a prodigy. He went to Westminster at eight, Oxford at twelve, and was entered at Lincoln's Inn at sixteen. His father's desire to see him on the Woolsack was prevented by Jeremy's failure in the Courts. After all the dazzling success of the prodigy, it looked as if life would do without him.

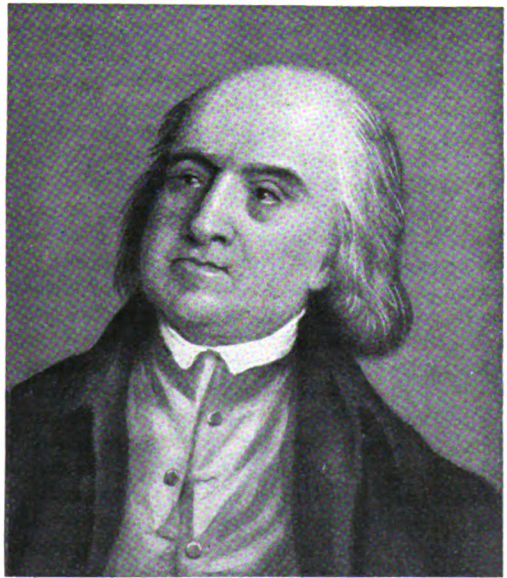
But while under the displeasure of his father, and living what he afterwards described as a miserable life, Jeremy wrote and published a work entitled "A Fragment on Government." In his law studies Bentham had discovered endless abuses of the

first magnitude; and when he found that Blackstone belauded the English Constitution as practically faultless, he was stung to writing this fragment on government. Its success was instantaneous. Bentham became the friend of so powerful a man as Lord Shelburne, and from that day his life was a progress in prosperity and fame.

It must be acknowledged that he owed no small amount of his fame to the brilliant French translations of his works by M. Dumont. Bentham only became tolerable and intelligible, according to Sydney Smith, after he had been washed, trimmed, shaved, and forced into clean linen. Certainly it was in France that our philosopher first attained popularity. On a visit to Paris in 1825 he entered one of the supreme law courts, was recognised, and immediately the whole body of advocates rose to do him reverence, while the judges invited him to take a seat of honour beside them.

In England it was not only the clumsiness of Bentham's style that stood in the way of his success, but certain fundamental deficiencies in his philosophy which were soon manifested by the reviewers. He was the philosopher of Radicalism; he demanded many of the reforms that have either come or are coming, but he failed to see that progress depends upon the education of the popular mind. Macaulay never ceased to do honour to Bentham as the father of Jurisprudence, but he offered the most brilliant, the most contemptuous, and the most shattering opposition to the upholders of the doctrine of utility which pervaded most of Bentham's political writings. "We apprehend," he wrote, "that many of them are persons who, having read little or nothing, are delighted to be rescued from the sense of their own inferiority by some teacher who assures them that the studies which they have neglected are of no value, puts five or six phrases into their mouths, lends them an odd number of the 'Westminster Review,' and in a month transforms them into philosophers." He spoke of them as "smatterers whose attainments just suffice to elevate them from the insignificance of dunces to the dignity of bores, and to spread dismay among their pious aunts and grandmothers."

Macaulay truly pointed out that Bentham's principle of "the greatest happiness of the greatest number"—a phrase which Bentham had adopted and made famous—was as old as the precepts of Christ, but that with Christ the injunction of the Golden Rule was accompanied by a sanction of immense force. "He should reflect that the whole vast world of morals cannot be moved unless the mover can obtain some stand for his engines beyond it. He acts as Archimedes would have done if he had attempted to move the earth by a lever fixed on the earth. The action and reaction neutralise each other. . . . Mr. Bentham can only tell us to do something which we have always been doing, and should still have continued to do, if we had never heard of the 'greatest happiness principle'—or else to do something which we have no conceivable motive for doing, and therefore shall not do." But, in spite of all this fine criticism, Bentham did undoubtedly give a fresh energy to political economy.

He dressed as a Quaker, lived like a

JEREMY BENTHAM

hermit, and, with the exception of music, knew nothing of the arts. He occupied Milton's old house in Westminster, and, though a delightful host to guests of his own invitation, kept his door shut against all intruders, even the most famous. Madame de Staël once sought an audience, and received the message that Mr. Bentham certainly had nothing to say to her, and could not see the necessity of an interview for anything she could have to say to him. Mr. Edgeworth, with his usual pomposity, sent this message by the servant: "Tell Mr. Bentham that Mr. Richard Lovell Edgeworth desires to see him." "Tell Mr. Richard Lovell Edgeworth," came the answer, "that Mr. Bentham does not desire to see *him*."

Jeremy Bentham lived to be eighty-four, and died on June 6, 1832. He left his body for dissection, and his skeleton stands in London to this day, dressed in his old clothes, at University College.

HENRI BERGSON
The Optimist of Creative Evolution

Henri Bergson was born in Paris, of Jewish ancestry, on October 18, 1859, the year of the publication of the "Origin of Species." He received a thorough academic education of the usual type, and in 1896 first made an impression upon the thinking world by his publication of the volume called "Matter and Memory," which may be looked upon as a stage of inquiry and preparation for his principal work. In 1900 Bergson was appointed Professor of Philosophy at the College of France, and that post he still holds. In 1907 he published his master-work, "L'Evolution Créatrice," which was translated into English by Dr. Mitchell, and published, in 1911, by Messrs. Macmillan, under the title of "Creative Evolution."

Thanks in part to the influence of the late Professor William James, the name and fame of Bergson have now spread everywhere, and made him, in a very short time, the central figure of contemporary philosophy, as he undoubtedly is. It was the intention of James, a generous and selfless thinker, had he lived, to have written an introduction to the English translation of "L'Évolution Créatrice." Its author has been honoured by academic invitations to lecture at the Universities of Oxford, London, and Birmingham, and has been, since 1912, the Gifford Lecturer at the University of Edinburgh. He is the new President, for 1913, of the Society for Psychical Research.

Since the publication of "Creative Evolution," Bergson has become the most conspicuous figure in that comparatively small but extremely distinguished band who are reasserting the claims of the mind to the supreme place in Nature, from which the mechanical science of the nineteenth century seemed to have deposed it, even in the realm of the living world. Bergson cannot with historical accuracy, however, be called the actual pioneer of the new movement. William James came before him, in his own individual and suggestive style, and notably Dr. Hans Driesch, of Heidelberg, whose work on the soul as a primary factor in Nature was published as far back as 1903. More recently the "new" school—which is as old as Anaxagoras—has received a notable English adherent in Dr. McDougall, of Oxford, so that it now has a representative of the first order in each of the three chief intellectual nations of the world.

As with Driesch and McDougall, Bergson's approach to the ultimate problems of the universe is scientific. He has received neither the long and stern training as a naturalist of the former, nor the medical training of the latter, but his route of access to our central problems has been especially psychological. His first task was a critical one, and it was made easier by the circumstances of his life and training. He came to the study of living nature in the country and city where Lamarck had taught and was honoured, so that, while making himself profoundly acquainted with the work of Darwin, he was not likely to fall under the spell of acceptance which that great student and his almost overwhelming champion, Huxley, wrought in this country between the year of Bergson's birth and the end of the nineteenth century.

For Bergson, as for everyone else in our time, universal evolution is a fact. We are all inheritors of Lamarck and Spencer and Lyell and Darwin in that respect. But, in preparation for his attempt to re-state the idea of evolution, in the light of modern knowledge, Bergson needed first to make a fresh and impartial survey of all his evolutionary predecessors, knowing well that, while evolution is a demonstrated fact, its how and whence and wherefore were still open to discussion. "Creative Evolution" is the result of that discussion, inscribing a new page in the history of thought; and the reader may be curious to note an apparent rhythm in the sequence of this history. Darwin was born in 1809, the year of the publication of Lamarck's great treatise. Fifty years later, Darwin published his contribution to thought, and forty-eight years later, the man who was also given to the world in 1859 published his volume in its turn.

The specific doctrine called "Darwinism," the theory of the origin of species by natural selection, has not survived the criticism of Bergson and others. In "Creative Evolution" we are clearly shown that the essential factor of organic evolution has been omitted altogether from the Darwinian theory. As a trained psychologist, Bergson had his eyes open to indications of mind, wherever they are to be found, just as the engineer sees mechanism wherever he looks, and the chemist is alive to the signs of

chemical processes. But the evolutionists of the nineteenth century had not been psychologists primarily, if at all, and they had missed what Bergson saw, the truth that it is impossible to explain the facts of life unless we invoke mind—the "Seele" of Driesch—as the *primum mobile*, or prime mover, of the whole process.

In a sense, but with a vast difference, this Neo-Vitalism, as it has clumsily been called by its commentators, is a return to the views which the nineteenth century evolutionists deposed. When they came upon the scene, the accepted theory may fairly enough be identified with the "Natural Theology" of Archdeacon Paley. Any living creature had only to be looked at closely in order to see that it had evidence in it of design, whence the older thinkers, such as Paley, inferred the Mind of a Designer, as we infer a watchmaker from a watch. The pioneer evolutionists combated this view. What had been called design was really chance, they said—the result of fortuitous variations, the most advantageous of which had been seized upon and maintained by natural selection.

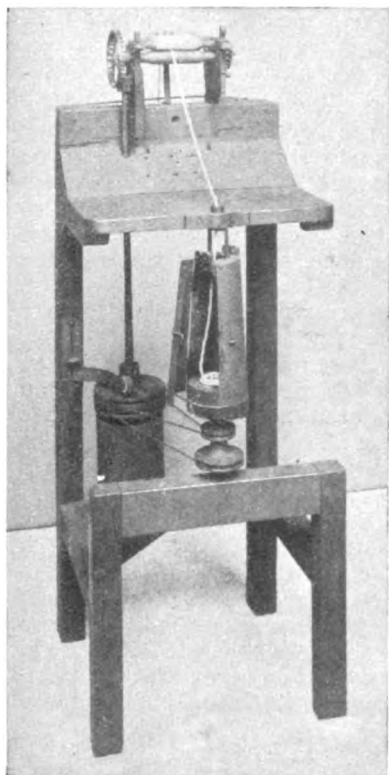
Modern vitalism, as represented above all by Bergson, declares that this explanation of organisms by chance is incredible, or, rather, no explanation at all, and maintains the importance of mind in a new-old sense. The accumulated facts of the behaviour of living creatures, carefully collected and studied by many students during the last twenty years, and especially during the present century, make imperative some recognition of purpose or design in life; but this, according to Bergson and all other evolutionists, is certainly not design as Paley understood it—the making of living creatures according to some preconceived plan or scheme in the mind of an Almighty Manufacturer.

According to Bergson, Life *is* Mind, and it is the architect of living beings. The whole history of life, of plants and animals and human beings, is the product of this psychical entity, Mind or Life—for the terms are synonymous—which becomes visible or incarnate in living organisms whenever the conditions of the physical world permit, and which everywhere exhibits a Striving or Push, which, in Bergson's famous phrase, is now called the "Élan Vital." He argues, further, that this mind or will, which we feel in ourselves, purposing and achieving *new things*, is the real creative force of the world. "The great error," he says, "of the doctrines about the Soul (or Mind) has been the idea that by isolating the spiritual life from all the rest, by suspending it in space as high as possible above the earth, they were placing it beyond attack, as if they were not thereby simply exposing it to be taken as an effect of mirage." That, of course, *is* exactly what the popular forms of religion and philosophy for the million have always done, as against the teaching that "the Kingdom of Heaven is within you," which no priesthood yet has ever been found to teach or tolerate.

No, says Bergson; spirit is neither an illusion, as "science" had said, nor an extra, introduced into man from above by some non-natural process. All life is the expression of spirit, which expresses itself most clearly in man, the highest product of the evolution of life. As he says, "Reality is a perpetual growth, a creation pursued without end. Our will already performs this miracle. Every human work in which there is invention, every voluntary act in which there is freedom, every movement of an organism that manifests spontaneity, brings something new into the world."

Already we can see that thought is advancing in its customary spiral. We seem to go back, with Bergson, to Lamarck, and even to Paley, but it is on a higher plane, thanks to the lift which we owe to the mechanical evolutionists of the nineteenth century. The appropriateness of Professor Bergson's new position, as President of the Society for Psychical Research, is evident. The very word "science," which seemed opposed to religion and to all recognition of the soul in man or in Nature, is beginning to take on a wider and a nobler meaning under the influence of modern vitalism.

Professor Bergson is still, and will be for some time, at the age when the greatest works of thought have been produced by their authors. His chief work has been exposed to an amount of study and criticism which cannot but be salutary, and we are entitled to hope that he has greater things yet in store for us and for those who are to come after us. His new and keen interest in eugenics, which seeks to exalt and amplify the human mind, is perhaps the best of existing omens for the progress of that "new factor in religion" in our time. Certain it is that a Bergsonian and spiritual basis for eugenics will alone be tolerated by the growing consciousness of the twentieth century.

MODELS OF THREE FAMOUS INVENTIONS

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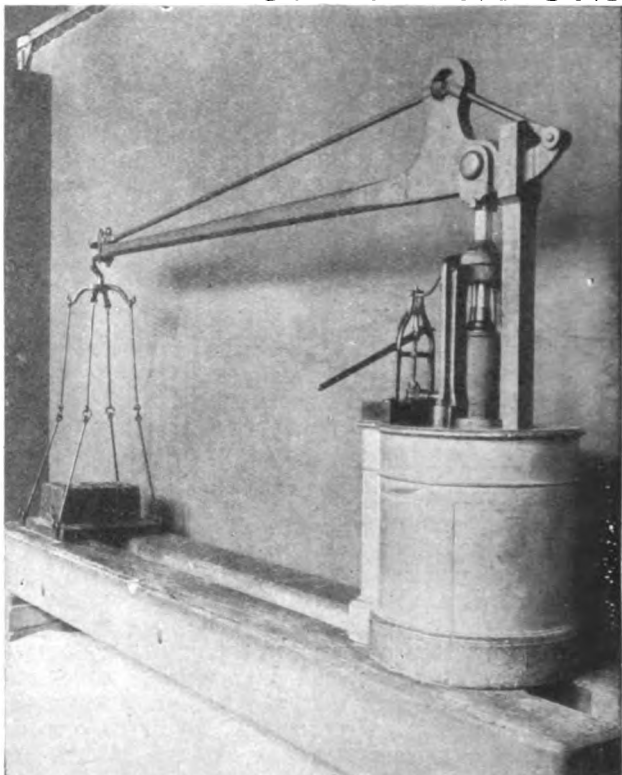
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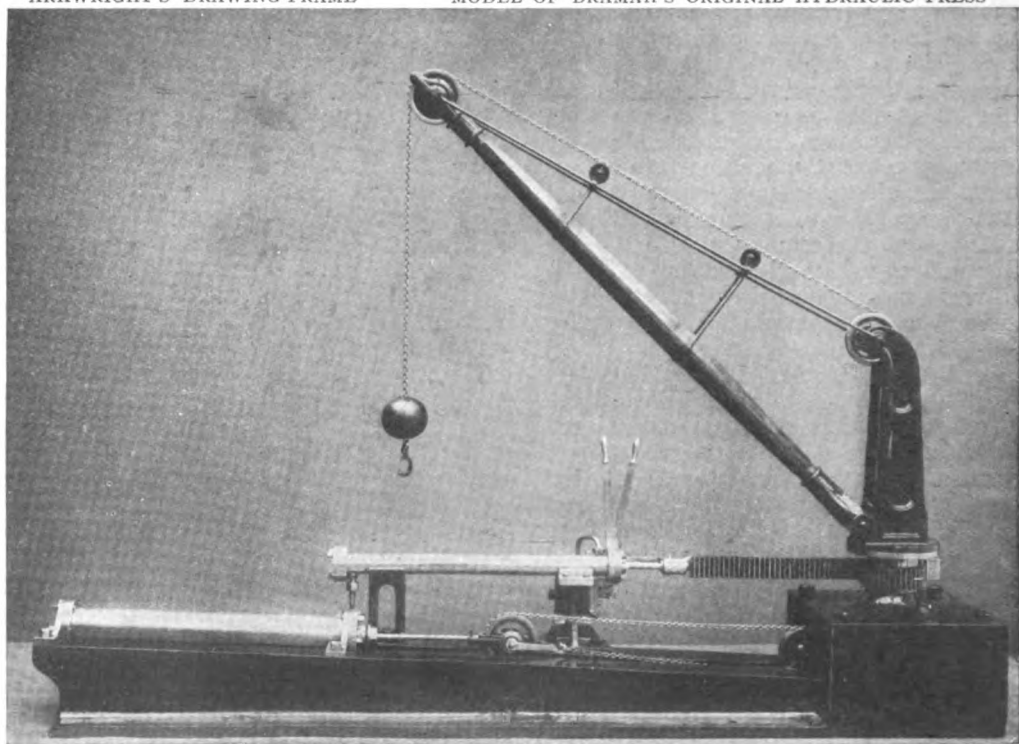
MODEL OF LORD ARMSTRONG'S HYDRAULIC CRANE

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INVENTORS

ARCHIMEDES

A Great Scientist before Christ

ARCHIMEDES was born B.C. 287, at Syracuse, Sicily, then one of the chief cities of the West Grecian world. The son of a geometer, and on terms of intimacy with Hiero, King of Syracuse, and with Gelo, his son, he was educated in part at the great school of Alexandria, and maintained a regular correspondence with the students of geometry of that city. Regarded as the most perfect type of scientific intellect that has appeared in the world, he appeals to the popular mind by his inventions, and to the scholar by his researches and discoveries in pure science. It was to science he was wedded. He scorned the mighty mechanical inventions of which he was the creator, and at which all the world wondered. He invented to order. Had he been living today, we should have asked him for the long-sought storage battery for electricity, or a stable aeroplane, and probably should not have asked in vain. King Hiero pished and huffed at his recondite studies, and asked for something tangible. As old Plutarch tells us, Archimedes regarded his inventions only as among the amusements of geometry. "Nor had he gone so far, but at the pressing instances of King Hiero, who entreated him to turn his art from abstracted notions to matters of sense, and to make his reasonings more intelligible to the generality of men, applying them to the uses of common life."

We have many King Hieros today who hold that science is valueless unless applied. Germany, in so far as she has beaten us in the race, has beaten us because she is prepared to take scientific investigation on trust, confident that something of value will result from every new important experiment. But Archimedes responded to his sovereign's call. He invented pulleys and windlasses, the water-screw or screw-pump, that endless screw which we find in operation today in sixpenny toys and some thousand-pound motor-cars; he invented various hydraulic and compressed-air machines; and the burning mirror, as to which the story is not disproved that he destroyed part of the Roman fleet when it appeared before the sea-walls of Syracuse. For the defence of the city against the army of Marcellus he created engines of war whose fame has ever since rung through the world, towering structures which suddenly rose above the battlements, to hurl stones or masses of lead against the assailants, which dropped beams endwise on their ships, or flung out hooks which, grappling the galleys, tilted them into the air, then let them fall slanting to the bottom of the sea.

Equally startling defensive measures met the attack on the land side, and the terrified Romans could but sit down and wait. They starved the city into surrender, but the operation took three years. Archimedes, having done his duty, and created the things for which he had been asked, had gone quietly back to his studies; and when the Roman soldiery broke in they found him pondering a diagram in the sand. It was by mistake that they slew him, for they had been expressly commanded by Marcellus to spare the distinguished man. Marcellus buried him in a noble tomb, which was discovered and restored more than a century later by Cicero. The tomb bore a representation of a cylinder circumscribing a sphere, with a verse indicating that Archimedes regarded as his greatest

achievement the measurement and mutual proportions of these two bodies.

The contributions of Archimedes to pure science have long been absorbed into the learning of the world to whose sure foundations he so greatly contributed. His results were attained by infinite patience, and also by brilliant intuition. Of the latter, the well-known story of his detecting the alloy in the king's crown is typical. Hiero had given a known weight of gold to an artificer with which to make him a crown, and, suspecting a cheat, asked Archimedes to tell him whether base metal had been substituted for any of the gold. Archimedes was puzzled until one day, stepping into a bath, he caused the water to run over. He had mastered the secret, and ran through the streets to his home in a state of nudity, crying, "I have found it!" It had flashed upon his mind that a body in water displaces a quantity of water of equal weight. It, therefore, the crown and an equal weight of gold were placed separately in a vessel of water and the overflow occasioned by each noted, the presence or absence of an alloy would be manifested. Starting from this point he composed his masterly treatise upon floating bodies, the first attempt made to estimate the pressure exercised by the elements of a fluid.

Archimedes died in 212 B.C. His works live after him. He was right, and his master was wrong; it is the results of his abstract studies that have mattered to the world. Some of his inventions have been in general use to this day, but his teachings are of the foundation of learning for all time.

SIR RICHARD ARKWRIGHT

A Founder of Modern Lancashire

Richard Arkwright, of spinning-jenny fame, was born at Preston, Lancashire, on December 23, 1732, the youngest of thirteen children, whose parents were extremely poor. He received but scanty education; and, indeed, it was not until he had turned fifty that he was able really to master spelling and grammar. He began his career early in a barber's shop, and, setting up for himself in a cellar at Bolton, displayed the sign, "Come to the subterraneous barber. He shaves for a penny." When his rivals brought down their prices to his level, Arkwright reduced his to a halfpenny. He married first in 1755, but seems soon to have been left a widower, for he married again in 1761, and, abandoning his barber's shop, set out as a travelling wig-maker. He bought human hair on his travels, and, utilising a secret chemical preparation, dyed his wigs the colour desired by his patrons.

By what steps he was led to the invention of his spinning-frame is not known, but cotton was king in Lancashire then as it is today, and to every cottage that he went its manipulation represented the bread of life. Up to 1767, when Hargreaves invented his spinning-jenny, the workers had been able to manage but one spindle at a time. The weavers had had to furnish themselves as well as they could with warp and weft for their webs, and, when the cloth was made, sell it wherever they could discover a market. At this time certain Manchester merchants began to organise the labour of the cottagers. They sent their agents far and wide, and supplied the weavers with foreign or Irish linen yarn for warp (that is, the stiffening cross-thread), and with raw cotton which before it could be used had first to be carded and spun by means of the old spindle or distaff, and then used as weft—the longitudinal threads. This stimulated the industry, but the demand for yarn far exceeded the supply.

Matters assumed a more promising aspect with the invention by Hargreaves of his famous spinning-jenny, which multiplied the number of spindles that the operative might use, from one to eight and afterwards more. But the resultant yarn was too soft for use alone; it had still to be combined with the linen warps; and it is interesting to recall, as a sidelight upon old trading methods, that the Irish manufacturers complained of the sale to England of Irish warps, as creating a scarcity in Ireland, and so forcing up prices. It was in 1767 that Hargreaves completed his jenny, though he did not patent it until three years later, and it is probably only a coincidence that in the former year Arkwright began his own investigations. There is no evidence that he knew anything of Hargreaves's invention; trade secrets were hoarded like a miser's treasure. But his vigorous intelligence had already grasped the theory of his spinning-frame, by which to abolish the old labour of work by hand, and at the same time to produce a thread stout enough to serve both as warp and weft.

It was in 1767 that Arkwright sought out one Kay, a clockmaker of Warrington, and asked him to make him the first model of his spinning-frame. The attempt was made, in later years, to prove that Kay betrayed the secret of another man to Arkwright, and that the latter's invention was in reality that of the man said thus to

have been wronged. The evidence of Kay is wholly untrustworthy, and there is every reason to believe that Arkwright's own account of the matter is correct—that he got his idea from seeing red-hot iron being drawn out through two pairs of rollers, the second pair moving more quickly than the first. Here, he thought, was a manner in which cotton, after being cleaned and loan of a smith and toolmaker for the heavier part of the apparatus; while Kay, under the instructions of his poverty-stricken master, undertook the clockwork part of the business. Arkwright gave 1768 as about the year of his invention, but stated that it was effected only after "many years' intense and painful application."

ARCHIMEDES WORKING OUT A PROBLEM AS THE ROMAN SOLDIERS COME TO KILL HIM

carded, might be treated. Arkwright threw himself wholly into his new scheme, gave up the wig business, and brought himself low pecuniarily, so that when he applied to a certain instrument-maker for assistance the man of substance turned in contempt from the unkempt genius before him. He did consent, however, to grant Kay the

When the first model was finished, the inventor, accompanied by Kay, set off to Preston, where they exhibited it in great secrecy to a possible patron in the parlour of the old Grammar School House. A striking picture has come down to us of the preliminary trials with the machine which was to endow Lancashire in particular, and

the nation generally, with such wealth. The care that they took to screen their operations created suspicion. Two aged women, living hard by the schoolhouse, seem to have crept fearfully on tiptoe into the gooseberry plantation before the schoolhouse, and to have told with fine imagination of the hideous witchcraft that was being practised within the little parlour, of the weird humming which suggested that the devil was tuning his bagpipes, and of Arkwright and his confederates dancing a hornpipe. In reality there was not much enchantment in the matter. The prosecution of his plans brought the inventor to such straits that, when he was asked to go to the poll to record his vote, he declined until those who sought his suffrage gave him a good suit of clothes in place of the rags to which he was reduced.

Lancashire was cotton mad; it was machinery mad in quite another sense; so, warned by the experience of others, Arkwright set up his first commercial machine in Nottingham, where, assisted by various enterprising people, he opened his first works, and drove his machinery by horsepower. This proving too costly a method, he established himself at Cromford, in Derbyshire. Here he had excellent waterpower, and began operations with success.

But the Lancashire manufacturers, who had been crying out for the very article that he had to offer, now refused to use it. They were prepared to injure themselves in order to ruin him. He was driven to stocking-making, and then to the manufacture of calico. His success was brief, for the men of Lancashire invoked an Act of 1736, designed to protect the woollen industry, by imposing a tax of threepence per yard on such fabrics when exported, and prohibiting its use at home unless it embodied a linen warp. But the indomitable Arkwright made representations to the Government, which brought about the repeal of this absurdity, and in 1774 manufacturers were free to fabricate "stuffs wholly made of the raw cotton wool."

In the following year, Arkwright patented a great development of his machine. The new method embraced the entire process of cotton manufacture, carding, drawing, roving, and spinning—a marvellous machine for such an age, and from the brain of a man entirely self-taught in mechanics. The invention gave an enormous impetus to the cotton trade of England. Supplies were vastly increased, prices for yarn and for the finished article were reduced, the output was multiplied a thousandfold. Forthwith Arkwright brought into being our factory system. He organised with care and with humanity, and, considering the character of his materials, achieved marvels.

But his real battles began only when success seemed assured. He built his own factories, he licensed other manufacturers to use his patents. Yet though individual and collective prosperity was increased by his invention, the masses hated his machines. They wrecked his mill near Chorley, while the police and military,

SIR RICHARD ARKWRIGHT

encouraged by his trade rivals, looked on with folded hands. Added to this, he had to combat the knavish practices of manufacturers who, while doing all they could openly to injure him, secretly stole his patents and set to work with his machines. The story of his legal battles is too long and complicated to be recounted here. In the end he was beaten on legal technicalities. His patents were cancelled, without, so far as we can judge today, a shred of credible evidence against their bona fides.

However, he still held an incomparable position in the manufacturing world, amassed a great fortune, and had the joy of attaining some degree of scholarship, and of seeing the country's trade increasing by leaps and bounds as the results of the labours of his mighty, untrained brain. He died at Cromford on August 3, 1792, six years after he had been knighted by George III.

LORD ARMSTRONG

The Clerk's Son who Revolutionised Warfare

William George, first Baron Armstrong, the inventor of the hydraulic crane and the rifled cannon, was born at Newcastle on November 26, 1810, the son of a clerk who became a corn merchant. Young Armstrong, though betraying a strong bent for mechanics, was articled to a solicitor, whose partner he eventually became, to practise law for thirteen years. His career as an inventor, really begun when he was still a child, had its rise in one of those happy accidents which only the inspired intelligence seizes.

While out fishing, he watched at work a water-wheel, upon which fell a stream that descended from a great height. He noted that only some twenty feet of the fall of several hundreds of feet were utilised, all the rest being unproductive. He conceived the notion that if the whole rill were conveyed by pipe, and caused to act by pressure at its base, the entire fall could be utilised. The idea germinated in his brain for some time, during which he closely applied himself to the study of hydrostatics, and by writing and speech, and an actual model, showed how effective a hydraulic crane could be made.

The opportunity arrived when he was enabled to construct, on Quayside, his first full-sized crane worked by hydraulic pressure, the power being obtained from the pressure in the water-mains of the Whittle Dene Company. The experiment was at once successful, and, the news becoming noised abroad, many scientific men visited Newcastle to see it.

One of these was Mr. Jesse Hartley, engineer of the Liverpool Docks, who, hating new-fangled notions, was yet persuaded, much against his will, to go unannounced to see the crane. Only the crane-man was on the spot, and he, in reply to the challenging banter of the stranger, put the crane through its paces in such a manner as to demonstrate its infinite superiority to any other. The result was that the visitor walked into Armstrong's office, to say: "I am Jesse Hartley, of Liverpool, and I have seen your crane. It is the very thing that I want, and I shall recommend its adoption at the Albert Docks." And he was gone.

The crane was adopted at Liverpool; it was adopted at all the great docks of our own land and others, and was the parent of all the multifarious forms of hydraulic machinery which are now found indispensable in every branch of industry where heavy weights have to be handled and great pressure exerted.

The gun-making side of Lord Armstrong's business was the outcome of his studies of the ineffective fire of our artillery in the Crimean War. The rifling of small-arms having effected a great improvement, why, he asked himself, should not the principle be applied with equal success to cannon? He tried to enlarge a rifle musket to the proportions of a field-gun, substituting leaden projectiles for balls of cast iron. He gave three years to the work and spent a thousand pounds on it, to have his piece described by the War Office as a popgun. He enlarged the bore, and was bidden make an experimental 18-pounder. After vexatious delays and quibbles, a special committee was appointed, which finally reported, after exhaustive trials, that the Armstrong gun was fifty-seven times as accurate as the Service weapon then in use. Armstrong presented the valuable patent rights to the nation, was knighted and appointed Engineer of Rifled Ordnance, while his firm was employed to carry out the work of constructing the guns.

The whole art and practice of warfare was revolutionised by his inventions in relation to lethal weapons. Afterwards the building of warships occupied his attention, together with the manufacture of steel and machinery. Among other inventions standing to the credit of this remarkable man was the hydro-electric machine, which has since, in a variety of forms, proved a powerful means for producing frictional electricity. This invention, perfected when he was only thirty years of age, brought him membership of the Royal Society. Lord Armstrong died at Craigside, Rothbury, December 27, 1900, having a few years previously bought Bamborough Castle, and endowed it as a pleasant home for cultured poverty.

CHARLES BABBAGE

The Man who Made the First Counting Machine

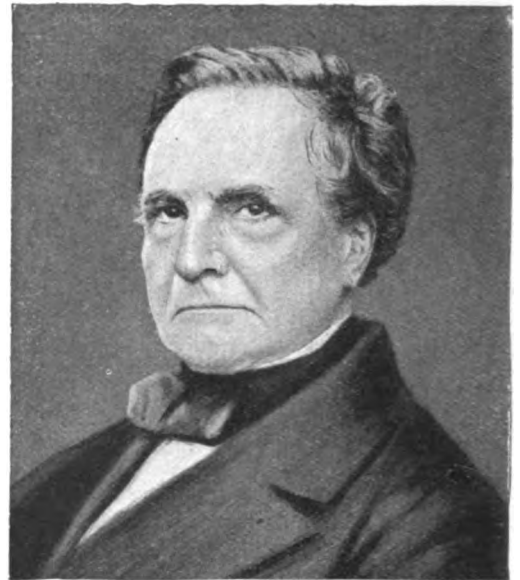
Charles Babbage, the maker of the calculating machine, was born near Teignmouth, Devon, on December 26, 1792. Being a delicate child, he was at first privately educated, but took naturally to mathematics, possibly inheriting this taste from his father, who was a banker. When he entered Trinity College, Cambridge, he found himself a better mathematician than his tutors, but profitably pursued his studies in company with Herschel and

Peacock, with whose assistance he founded, in 1812, the Analytical Society. The three friends published, four years later, a translation of Lacroix's "Elementary Treatise on the Differential and Integral Calculus," and two volumes of "Examples" with their solutions, volumes which, it is declared, gave the first impulse to a mathematical revival in England.

Quitting Cambridge in 1814, Babbage established himself in London, became a Fellow of the Royal Society two years later, but in later life poured scorn upon the methods of this body, and by his criticisms helped materially to found the inestimable British Association. He also took an active part in founding the Astronomical Society. While associated with Herschel in repeating Arago's experiments on the magnetisation of rotating plates, he invented the astatic needle, this being a needle without polarity, having its directive property destroyed by the proximity of another needle of the same intensity fixed parallel to it, but with the poles reversed. But it is upon his work in connection with the calculating machine that the fame of Babbage depends.

Primitive calculating machines for the performance of single arithmetical operations had been in existence since the seventeenth century, when the first was invented, in 1642, by Pascal. Babbage fashioned a machine which calculated an entire table, the principle being worked out as the result of refined mathematical processes which gave him for basis the "method of differences." The numbers composing nearly all arithmetical series can be formed by the repeated addition to fundamental numbers of a common difference or element, for which work, as he demonstrated, machinery was eminently fitted. By means of his machine he hoped to eliminate many of the serious errors which had crept into astronomical, navigation, and other tables. The invention was favourably reported upon by eminent scientists, and the Government of the day agreed to subsidise the inventor. Elaborate workshops adjoining Babbage's house were eventually set up at the cost of the Government, and in these were fireproof rooms designed to receive his precious drawings and the valuable tools he had invented for the work.

The machine was never really completed, for, before it reached its final stage, the fertile mind of the inventor saw infinitely greater possibilities for a machine of greater scope, which was to be not a "difference" but an analytical engine. Eight years passed before he could get the Government to declare whether or not they would continue his patron. At last they decided against further expense. In addition to £6000 that he had spent, the Government had laid out £17,000 and the goal had not been reached. So the great scheme fell to the ground, and only models and drawings remain of a machine which was to revolutionise mathematical science.

Since the day of Babbage many and wonderful calculating machines have been invented, but he was the great pioneer. His writings, his own work, his betterment of tools, paved the way for others with energy sufficient to push home their theories, a faculty which Babbage, with his indifferent health and nervous excitability,

CHARLES BABBAGE

seemed to lack. He complained that street-organs and other noises had robbed him of one-quarter of his entire working power. After thirty-seven years of practically abortive work at the calculating machine which never actually calculated, Babbage was a little embittered against his generation, but he was still a charming companion to those with whom he was in sympathy.

Lord Playfair, one of his intimates, has left us a pleasant picture of the fascinating conversation of Babbage. The latter was at work at the time upon a scheme of signalling by lamps—a scheme by which the Russians profited, by the way, during

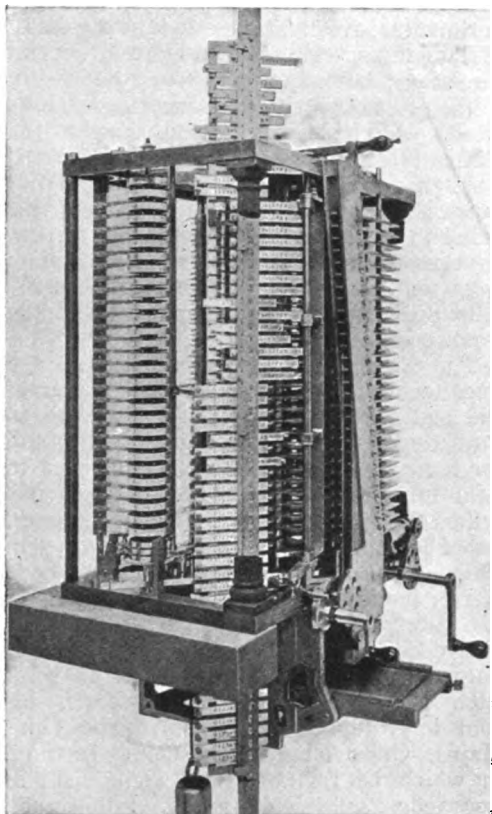
the siege of Sebastopol. "Babbage," says Lord Playfair, "was a man full of information, which he gave in an attractive way. I once breakfasted with him at nine o'clock. He explained to me the working of his calculating machine, and afterwards his methods of signalling by coloured lamps. As I was engaged to lunch at one o'clock, I looked at my watch—which indicated the hour of four. This appeared obviously impossible, so I went into the hall to look for the correct time, and, to my astonish ment, found that the hour was four. The philosopher had, in fact, been so fascinating in his descriptions and conversation that neither he nor I had noticed the lapse of time."

Babbage paid great attention to the factory and workshop practices of England and of the Continent, and his "Economy of Machinery and Manufactures" was described by an eminent critic as the hymn of machinery. The work was quickly translated into four languages. All his writings attracted much attention, and he was received abroad with great honour. If he failed to reach finality with his own inventions, Babbage vastly stimulated others, and was a considerably greater force in the nineteenth century than is now commonly recognised. He died at his house in London on October 18, 1871, within sight of his beloved workshops.

The rudiments of the machine which he and his friends believed was to quicken the application of science to every department of human life were removed to South Kensington Museum. Seven years later a committee of the British Association examined the drawings, and reported that the successful realisation of the machine might mark an epoch in the history of computation equally memorable with that of the introduction of logarithms. The drawings, however, were not sufficiently advanced for the committee to advise any attempt to continue the work.

ROGER BACON

The Wonder-Man of the Middle Ages

Roger Bacon, the father of modern scientific learning, was born, of good family, upon an unknown date in 1214, at Ilchester, Somerset. Perhaps the most fascinating figure of his era, the monkish philosopher-inventor was far in advance of his time. His knowledge of the law of optics enabled him to invent the magnifying-glass (see page 964); and he described a telescope, though whether he wrote of a possibility or as of something that he possessed there is nothing to show. He may have had some primitive form of this instrument which was to revolutionise our knowledge of astronomy, but the evidence seems against it. That he invented, or at least knew how to create, gunpowder, seems to be beyond question. He investigated and explained the nature of the rainbow, and his writings led later to

BABBAGE'S ANALYTICAL ENGINE

the invention of spectacles, as, in another connection, they inspired and encouraged Columbus for his quest of the New World.

These achievements of Bacon were very remarkable, considering the age in which he lived, and they were still more remarkable when we remember the extraordinary circumstances in which they were effected. Although his family had been impoverished in the troublous times of Henry III., there remained sufficient of the estate to support him, and apparently certain brothers, at Oxford, where, before he reached manhood, he took Orders, though it was not until about 1250 that he became a member of the Franciscan Order. After quitting Oxford he studied and taught in Paris, which was

then the centre of the intellectual life of Europe. Here he took his degree as doctor of divinity, and became known as "Doctor mirabilis." His fame preceded him to Oxford, whither he returned at about the time that he became a Franciscan.

The shallow pretentiousness and insincerity of the scholiasts had by this time disgusted the enthusiast, and he threw himself into the study of physics, into experimental investigation, and into the study of languages. He reached light in several directions, but in others groped hopelessly in the gross obscurity of the age in which he lived. He believed in and sought the elixir of life and the philosopher's stone; and, though he insisted that mathematics must be the foundation of astronomy, his belief in astrology led him to declare that by thus mastering the secrets of the stars we should cause them to exhibit to us the influences regulating temperament and the predisposition of character.

The Franciscans could not tolerate the unconventional teaching of this mocker of the bad old ways, and he was ordered to Paris, kept under strictest surveillance, and for ten years forbidden to write or even to hold intercourse with his kind. His one influential friend was Guy de Foulques, papal legate in England. He, on being, in 1265, elected Pope (Clement IV.), bade Bacon ignore his superiors, and write him his views on science and learning. "The marvellous doctor" had, so far, written only scattered tracts, but he set to work with fiery zeal and poured forth his soul in voluminous tomes, in the Opus Majus, Opus Minus, and Opus Tertium, in which he reviewed the whole field of knowledge, physical, moral, intellectual, and theological. The writings were in effect a magnificent plea for the intellectual emancipation of the nations, for freedom from the false and foolish teachings of prelate and scholiast.

How much of his writings actually reached the hand of Clement we do not know, for the whole could not have been completed before the Pope was seized with his last illness. Clement died in 1268, after reigning only three years, and Bacon was left to the mercy of his enemies. From the comparative freedom to which the protection of Clement IV. had restored him, he was cast again into captivity, being indicted for sorcery and heresy. He seems to have regained his liberty in 1292, and to have died at Oxford in 1294, but there is no reliable guide to the actual year.

The cloud of suspicion under which the great inventor-thinker lay made his writings for long comparatively a closed book, but little by little his teachings came to light, to bear abundant fruit. Modern scientfic inquiry begins with him; and though he could not penetrate the mists which hid the absurdities of alchemy and astrology, to his labours in these fields may well be applied the saying of Francis Bacon: "The pursuit of alchymy is at an end. Yet surely to alchymy this light is due—that it may be compared to the husbandman whereof Æsop makes the fable, that when he died, told his sons that he had left unto them a great mass of gold buried underground in his vineyard, but did not remember the particular spot where it was hidden; who when they had with spades turned up all the vineyard, gold indeed they found none; but by reason of their stirring and digging the mould about the roots of their vines, they had a great vintage the year following: so the painful search and stir of alchymysts for gold hath brought to light a great number of good and fruitful experiments as well for the disclosing of nature as the use of man's life."

JOHN BAILEY

The Benefactor of Every Ploughman

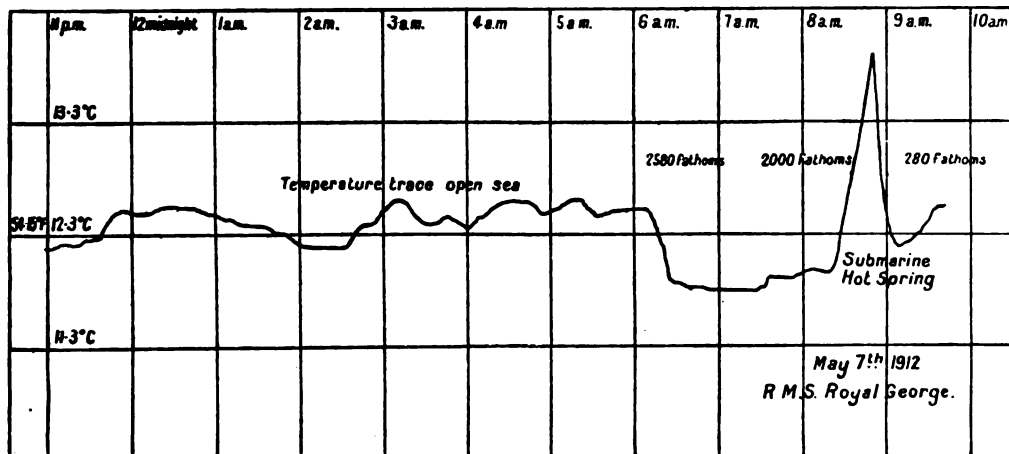
John Bailey, born at Blades Fields, near Bowes, Yorkshire, in 1750, was the inventor of the modern plough. When the nineteenth century dawned, the ploughs in use in many parts of Europe were as primitive as those which had been employed by the ancient Egyptians and Greeks. They consisted simply of the trunk of a tree from which the pointed ends of two branches projected at acute angles, one forming the ploughshare, the other the handle by which the man behind it guided and pressed down the share. The team consisted of men, and afterwards of cattle or horses. Some of our British ploughs could not be worked save by the labour of eight oxen. Bailey was by instinct an artist, with a leaning towards mathematics. He first acted as tutor to the children of a prosperous uncle, and then, after a spell as land surveyor and teacher of mathematics, settled down as land agent to Lord Tankerville at Chillingham. Here, in addition to effecting some admirable engravings for publication, he devoted considerable attention to mineralogy, chemistry, hydraulics, and pneumatics, and in 1795 published an essay on the construction of the plough, in which he demonstrated, by mathematical calculations, the advantages of the implement which he

proposed. The ploughs of many modern makers each possess their distinctive features adapted to varying conditions, but that invented by John Bailey, the Yorkshire artist - engraver - mathematician - surveyor, was the first rational plough ever designed. He died on June 4, 1819.

HOWARD T. BARNES
Making the Iceberg Speak

Professor Howard T. Barnes, one of the brilliant school of younger scientists which the Dominion is evolving, was born at Woburn, Massachusetts, on July 21, 1873, educated at Montreal Academy and McGill University, and in 1900 won the coveted Joule studentship. In the course of a strenuous scientific career, which has gained him his degree as doctor of science and Fellowship of the Royal Society, he has made valuable contributions to the common stock of knowledge as to specific heats, ice formation, radio-activity, and refined electrical measurements. So far as can be estimated, his chief claim to fame as an inventor is to rest upon the micro-thermometer which he has perfected. This instrument, in view of the loss of the "Titanic," possesses a special interest for both the Old World and the New, for it is primarily intended for the detection of ice at sea.

After twenty years' study, Mr. Barnes came to the conclusion that careful navigators are in the right when they say that the temperature of the ocean, as read by the ordinary ship's thermometer dipped into a bucket of water drawn from the sea, is of no value as a guide to the proximity of ice. His own experiences were supported by the experimental investigations of Dr. Otto Petterson, who has discovered three important laws as to the behaviour of ice melting in salt water. Such ice produces three currents, which may be explained as follows: (1) When the ice melts it cools the salt water, which sinks by convection; (2) a stream of warmer salt water moves in towards the ice, giving rise to a horizontal current; (3) the melted ice consists of fresh water, which does not mix with the salt water, on account of the difference of density. This fresh water rises around the ice and spreads out over the surface. The ice becomes surrounded by a layer of fresher water, which tends to remain on the surface. As the ice moves, the fresh water moves with it. Waves do not mix it with the salt water, but leave it practically unaffected.

For the purpose of his own work, Mr. Barnes constructed a highly sensitive

HOW THE MICRO-THERMOMETER REGISTERS THE VARYING TEMPERATURES OF THE OCEAN

electrical resistance thermometer, which, when placed in water, not only measures changes of temperature so minute as a thousandth of a degree, but registers those changes on a chart contained in the officers' room of the ship. The thermometer was first applied to the St. Lawrence, with the interesting result that the waters of that river during the winter are shown "not to vary more than a minute fraction of a degree from the freezing-point." The small variations that have been observed and measured are the result of heat exchanges when ice is present, and they accompany the formation or disintegration of ice.

"The delicate poising of the forces of Nature," says the inventor, "are here wonderfully illustrated. A few thousandths of a degree on either side of the freezing-

point of the river water may produce immense physical effects. Thus the character of a river may be changed in a single night, or the wheels of the largest hydro-electric station completely stopped by a drop of a few thousandths of a degree. As a result of this knowledge, it is now possible to apply artificial heat round the wheels and gates, and completely prevent any trouble from the sticking of ice needles drawn in by water."

Experiments with the micro-thermometer at sea as a berg-detector produced results of a surprising character. What the inventor calls the iceberg-effect first manifests itself in a rise of temperature, followed by a slight fall. The decline is not as great as would be expected, and would probably be so inconspicuous on the ordinary thermometer as to pass unnoticed, but on the micro-thermometer it is clearly shown. The rise in temperature experienced when an iceberg is first detected Mr. Barnes explains as follows: "It is evident that the iceberg effect is caused by the fresh water, observed by Petterson in his tank experiments, diluting the sea water, and creating a blanket of lighter water in which the sun's heat is absorbed. The warming of the open sea is offset by the vertical circulation, but in the fresher and lighter water this is impossible, and the warmer water remains on the surface."

The approach to land, however, is marked by a decided fall in temperature, due, the inventor explains, to the land turning up the colder undercurrents of the sea. The same effect is produced by shoals, of which the micro-thermometer, trailing in the water, records its warning upon the chart whereon it writes its messages. Among other trips, the micro-thermometer was tried all the way from Canada to England and back again, and gave notice as to ice infallibly. Moreover, it recorded the presence of a submarine hot spring when passing over the great wall of the continental shelf, about 400 miles west of the Irish coast. At this point the temperature rose 1½ deg., and then returned to the normal as the ship passed on.

His final conclusions as to iceberg effects in the ocean lead Mr. Barnes to an interesting statement, based on the strange rise of temperature recorded, even at a distance of twelve miles, by the micro-thermometer: "No better example could be had of Nature's wise provision for the elimination of obstructions detrimental to her purposes than in the warming of the sea water by the action of the melting iceberg. In this way a berg, by its own action, becomes surrounded by a zone of warmer water, which rapidly attacks it and causes it swiftly to disappear." Professor Barnes, who lectured on the subject at the Royal Institution in London in May of 1912, has since presented an exhaustive report on the matter to the Canadian Government.

FRITZ BERNHARD BEHR

The Pioneer of a New Travel Age

Fritz Bernhard Behr, the pioneer in England of the mono-rail, has been a naturalised Englishman since 1876, but he was born in Berlin on October 9, 1842, the son of a noted scholar. Educated in Paris, he afterwards became a pupil of Mr. Wentworth Shields and of Sir John Fowler, and gained practical experience in railway construction on many great British and Continental undertakings. Before he was thirty he was recalled to the Fatherland to take part in the Franco-Prussian War, was decorated for military services, and, at the close of the war, was given administrative control of part of the conquered territory. Released from military duty, he turned from the governance of captured provinces to the peaceful arts of the engineer, returned to England, and made himself as English as legal formality and his natural sympathies could render him.

Thoroughly versed in the old art of railway building, he sought to better the plan of his mentors, and devoted himself almost exclusively to the development of the mono-rail. This is a railway in which the train runs upon one line. That is to say, the weight of the train is borne upon a single line, while little guide-lines, one on each side, prevent swaying or oscillation, especially at curves. But these are only a concession to the conceivable timidity of passengers, and are not a necessity.

The principle of the mono-rail is simple. The rail is raised above the bed, being carried on the summit of A-shaped trestles, the legs of which are securely bolted to the sleepers. The train sits astride the line, as it were. The car is divided by a longitudinal gap, so that the sides of the carriage hang down, half on one side, half on the other side of the line. The flanged wheels which carry and drive the car are mounted at the top of the gap. The centre of gravity is below the rail, hence the car cannot overturn, even when rounding the sharp curves which it is able to negotiate. The principle, in primitive form, has already been employed in Algeria with mules as motive power. Mr. Behr, however, after a lengthy exhibition of a

steam model of his train on the site of what is now the Westminster Roman Catholic Cathedral, established a full-size railway in Kerry to connect Listowel and Ballybunnion, where since 1888 it has worked quite satisfactorily.

He exhibited with great success, though at an initial cost to himself of £40,000, a high-speed railway of the type at the Berlin Exhibition of 1897. This train ran at a speed of ninety miles an hour. Since then he has diligently worked at the scheme for a similar railway, but on a larger scale, between Manchester and Liverpool. By Acts of Parliament of 1901 and the suceeding year he is authorised to institute a mono-rail system connecting these two great cities by a service of electric trains which are expected to run at speeds up to 120 miles an hour. Each train is to consist of one car, but these are to run every ten minutes, and do their own signalling.

FRITZ BERNHARD BEHR AND THE MODEL OF HIS MONO-RAIL

ALEXANDER GRAHAM BELL

Carrying Speech Across the Earth

Alexander Graham Bell, inventor of the telephone, was born in Edinburgh on March 3, 1847, and educated at the university there and at London University. Both his father and grandfather had been keenly interested in the education of deaf-mutes, and young Bell followed them. Having completed his education, he went with his father to Canada in 1870, made himself master of his subject, and passed on to the United States, where he was appointed Professor of Vocal Physiology at Boston University. Six years later he exhibited an electrical invention by the aid of which he sought to make speech visible. That instrument was the beginning of the telephone. It was designed not indeed to enable the deaf to hear, but to see speech. The actual words themselves did not, of course, become visible. Speech caused a delicate metal reed to vibrate and to transmit an electric current to the opposite end of a wire, where the vibrations of the first reed were reproduced by a corresponding reed placed near a second magnet. The process is fully described on page 704 of this work.

While he was experimenting in this direction he discovered that he had approached the solution of a problem far mightier than he had contemplated. Instead of serving the deaf only, he had within his grasp the potentialities of a scheme which could serve all mankind. For the machine, by modification and refinement, was made to transmit not merely the vibrations of the reed; it

carried sound, resolved it into waves, transmitted them in that form, rebuilt them at the other end of the wire into sound —the tones of the voice which had uttered the sound.

It is one of the great romances of science that, upon the very day that Graham Bell entered his invention at the United States Patent Office, another man, Elisha Gray, also patented a telephone. The world had waited from the beginning of time for such a contrivance, and now two men arrived almost simultaneously, each to claim protection for his design. Gray patented his on the morning of February 14, 1876; Bell followed a few hours later the same day. But from the Scotsman's contrivance, with various improvements and modifications, the modern telephone has arisen.

Thus the telephone, which is now an indispensable adjunct to the daily life of the entire civilised world, is but thirty-seven years old, and results from the benevolent attempt of an inspired brain to put the few deaf in communication with the rest of humanity. The long line of experience, ending in one half of a continent being put into instant communication with the other half, began with tests made by the first instrument upon a dead man's ear! The rest of the amazing story will be found at the page indicated.

It remains only to be added that Mr. Bell has followed up his master-invention with ingenious contrivances for the transmission of sound by variations in a beam of light, and for the improvement of the talking-machine, and the induction balance. He has contributed ungrudingly to the scientific literature of the period, and remains a foremost authority on the treatment of the deaf and dumb, and on the mechanism of speech.

HENRY BELL
Father of Steam Navigation

Henry Bell, the son of a wheelwright, was born at Torphichen Mill, near Linlithgow, on April 7, 1767. He received the customary education of the parish school, and, after escaping apprenticeship to the calling of a mason, was allowed to follow the trade of his father. He gained experience in the service of several firms, both as shipwright and engineer. The idea of steam navigation was occupying many minds at the time, and it is said that Bell assisted in building the little steamship constructed for Symington which, launched in 1802, was allowed to rot upon the river bank because the wiseacres of the period declared that its wash would destroy the banks of the Forth and Clyde Canal. But Bell was in 1800 already experimenting with an engine placed in a small vessel, and in that year, and again in 1803, he approached the Admiralty with a view to gaining their support. Needless to say he was unsuccessful, although it is stated that his second appeal was backed by Nelson, who was reported to be in favour of the project.

Bell went on unaided, undeterred by the strictures of the usually far-seeing Sir Joseph Banks, who said of steam navigation, "A very pretty plan, but there is just one point overlooked—that the steam-engine requires a firm basis on which to work." Happily, Bell believed in himself and his theories, and in 1812 his famous little vessel the "Comet" was launched, a thirty-ton vessel, driven by a three-horse-power engine, which Bell himself had made. She began at once to ply between Greenock and Glasgow, the fares being three shillings and four shillings, according to class, and the speed 7½ miles per hour. She ran for eight years, and was then wrecked.

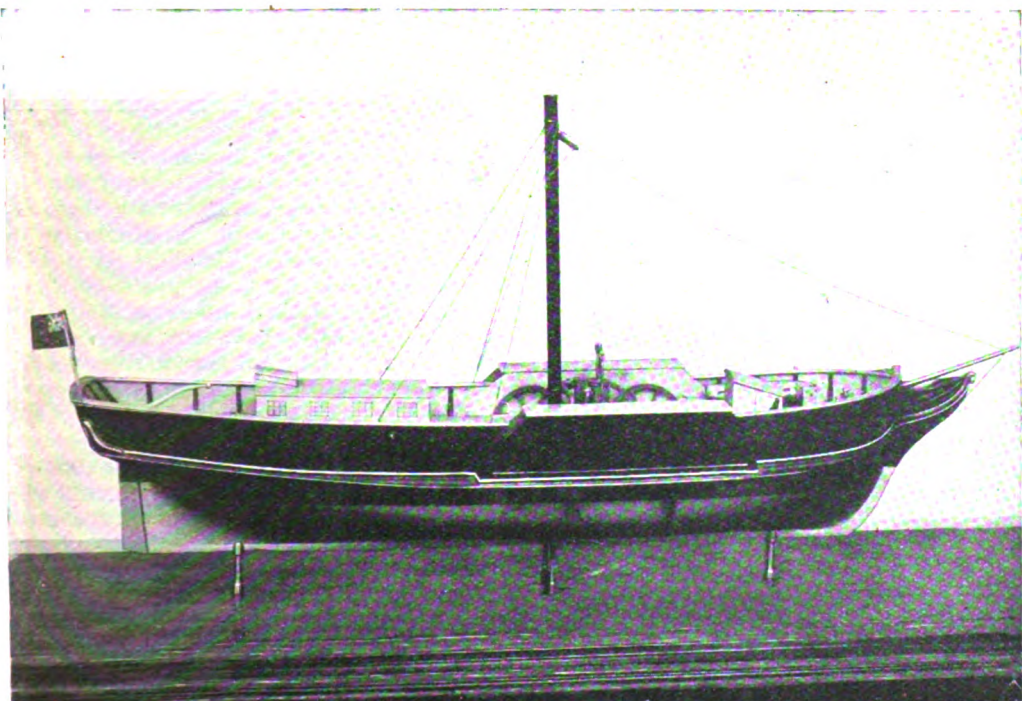
The "Comet" was not the first steamship in Great Britain, but she was the first practical vessel, and the first to run regular passages. Steam navigation on a large scale became possible, indeed inevitable, the day that she landed her first consignment of passengers and cargo at Greenock. Bell reaped small direct reward from his enterprise, but as he advanced in years the Clyde Trustees awarded him at first a £50, then a £100 pension, while the citizens of Glasgow, having ceased to regard his vessel, which ran against wind and tide, as an invention of the evil one, raised a sum of money for his benefit by public subscription. Bell, who also brought about an important improvement in the calico-printing process, died at Helensburgh on November 14, 1830, and today is commemorated by a memorial on the banks of the Clyde.

EMILE BERLINER
How He Made the Gramophone Possible

Emile Berliner, the inventor of the gramophone and in part of the modern telephone, was born in Hanover, Germany, on May 20, 1851. He was brought up in the Jewish faith, but at the present time he holds to no creed, and devotes himself to the service of humanity. In America he is one of the leaders of the public health campaign, which is effecting much improvement in the bodily welfare of the people. Dr. Berliner settled in the United States in 1870, and,

after a long and bitter struggle, he was, at the the age of twenty-six, only an overworked and broken-down salesman at Washington. Not content with his daily round of toil, he gave up his nights to the study of science, being especially interested in electricity. In order to unite practical experience and theoretic investigations, he learned telegraphy. One evening he was trying the key in a fire-alarm station in Washington, when the skilled operator told him to strike harder, explaining that by using more pressure the current was made intenser, and the sending distance was increased.

The operator was unable to account for this curious fact. He was one of those too practical men who are content to know that a thing is so. But the young salesman was interested in the theory of the matter. He had sat up at night studying the problem that baffled the inventors of the telephone—the problem of getting a clear reproduction of the voice. He now saw in a flash that differences in pressure could be made use of in a new kind of transmitter. Instead of the iron membrane and magnet employed by Dr. Bell—that transmitted very feeble sounds—he constructed a microphone transmitter which reproduced much louder effects. In 1877 his invention—that made practical telephony possible—was finished, and so, almost, was the young inventor. The strain of working as a salesman by day and as a scientific investigator at night was too heavy. Dr. Berliner had just strength enough to win his first victory in science; then he was utterly overcome by nervous prostration.

Happily, the new transmitter was acquired by the newly organised Bell Telephone Company, and in about a year the young inventor was lifted above poverty and uncongenial toil, and able to devote himself entirely to the scientific work in which he delighted. In 1878 he further improved the telephone by using an induction coil in the transmitter. Then his interest in the electrical side of voice-reproduction was somewhat diminished by a growing attraction to the mechanical aspect of the problem.

THE MODEL OF HENRY BELL'S "COMET" AT THE SOUTH KENSINGTON MUSEUM

He wanted to do for the talking-machine what he had done for the telephone. Being a man with a logical, analytic mind, he has never struck out a great original idea; he requires something concrete to work upon, something invented by men with a more constructive imagination. He then brings his talent for laborious analysis to bear upon the problem, and, after finding out what is the defect of the original invention, he thinks out a logical scheme of research,

directed to a definite end, before he begins his experiments.

In the case of the early talking-machines, he came to the conclusion that the method of recording sound-waves by the varying depths in a groove of wax was defective. Sounds were represented by innumerable hills and valleys at the bottom of tiny ravines in the waxen disc. The greater the depth of one of the valleys, the greater the resistance that the wax offered to the stylus. So the record could not be exact. And when the sounds were reproduced by sending another stylus jolting down the ravines, and communicating its vibrations to a membrane, there was often a tendency for the stylus to jump from one hill to another, and neglect the valleys. Such, at least, were Dr. Berliner's views.

Remarkably simple was the means by which he overcame these defects. He kept the stylus steady by making it run along a level groove in the wax. It was in the sides of the groove, and not on the bottom, that the sound-waves cut out minute caves and headlands. The sideways action or motion of the stylus is the original principle of the gramophone, invented by Dr. Berliner in 1887. By keeping the groove at a constant depth, the use of an expensive mechanical screw to guide the stylus is avoided, for the level groove acts as an admirable guide. Thus the mechanism of the new talking-machine is simplified, and at the same time a higher accuracy of reproduction is obtained.

Dr. Berliner is not a man of many inventions; he gets his results by hard work and hard thinking, and he aims at immediately practical results. He eyes the prize before he enters the race. His last invention of importance was an air-cooled engine with revolving cylinders, which he designed in 1907 for use in flying-machines. Having by careful living and diet nursed himself back to robust health after the nervous breakdown of his early manhood, Dr. Berliner has grown deeply interested in all matters of national health. For the last twelve years he has conducted in Washington a campaign against unclean methods of handling the general milk supply. The Milk Conference that met in Washington in 1907 was planned by him. He feels certain that progress in science and sanitation will at last free the younger generations from the widespread hazard of early death, and, by his philanthropic and educational labours, he is doing an important share in the noble task of saving mankind from preventable disease and disaster.

SIR HENRY BESSEMER

The New Era in Steel

Sir Henry Bessemer, the great steel-maker, was born at Charlton, near Hitchin, Hertfordshire, on January 19, 1813, and, like many other notable contributors to the welfare of the British nation, was of Huguenot descent. The son of a genius whose talent profitably expressed itself in die-sinking and type-founding, young Bessemer practically lived for a time in the workshops which his father had set up in the Hertfordshire village. Reaching London at the age of seventeen, with a brain teeming with original ideas, he evolved invention after invention, all more or less profitable. Thus he originated the first practical electro-plating plant; devised new and improved methods of embossing metals and other materials, and then made the nation a present of £100,000 a year. There was a touch of tragedy in this, though the issue was fortunate.

The Revenue authorities were losing this sum through the frauds of many persons in re-using deed-stamps. Bessemer devised perforated dies, by the use of which every stamp could be dated. This killed the dishonest practice in question, and saved the Government nearly two thousand pounds a week. Bessemer was to have been rewarded with a lucrative post, but Governments, like individuals, sometimes forget their obligations, and he never made a penny out of his invention, though a knighthood which came forty years later was regarded as a sort of conscience money paid by the Government.

But Bessemer would have been the first to admit, as a consequence of this adventure, that there is a divinity which shapes our ends. Had he obtained the promised appointment he might have settled down to comfortable inertia, and the world would have waited in vain for its Bessemer steel. Better and cheaper steel would inevitably have come, but not when it did; and to-day we should have been short of thousands of miles of railway track, of bridges, and other engineering undertakings.

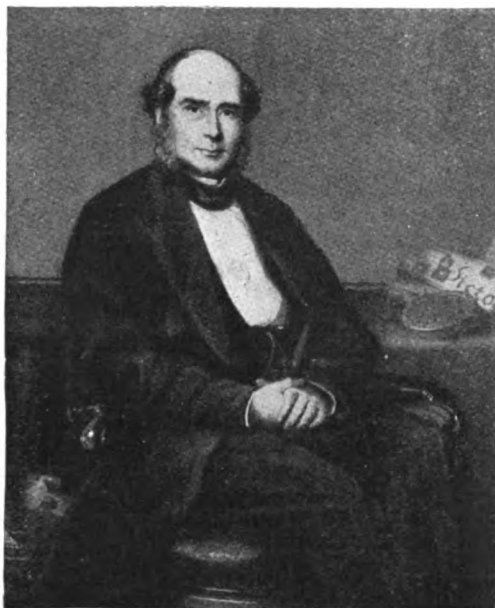
We could not have had the new steel without another happy accident. Bessemer hit upon a secret process for manufacturing bronze powder and gold paint, which then sold at £5 10s. per pound to printers and decorators. These powders were produced by hand at heavy cost in labour. Bessemer invented a machine which did the work more expeditiously and better. He was able to put it on the market at once at £4 per pound, and he kept the secret to himself for a generation, at the end of which time he was

selling at one-sixteenth of the price at which he had started. But for the bronze and gold powders he could never have obtained the capital necessary for his venture into the world of steel.

He was tempted into this field by the same events which attracted the attention of Lord Armstrong. The British army in the Crimea was furnished with utterly inadequate artillery. Bessemer set to work to rifle, not the cannon, but the projectile, but found that the metal of the existing guns was not strong enough to withstand the strain imposed. He at once began to seek a better material. Beyond experience with alloys in relation to other metals he knew nothing of the subject, but the knowledge he did possess induced him to attempt the fusion of cast iron with steel. He succeeded in getting his new metal, but it wholly lacked the properties desired.

While experimenting, he chanced to discover, when melting grey pig-iron in a certain type of furnace, that some fragments of the iron, which had been exposed to the air-blast, lay on one side, clear of the fire, and remained solid, in spite of the intense heat. At the end of a further half-hour, he found them in the same position. Taking an iron bar with the intention of pushing them into the fire, he found that they were merely the shells of decarbonised iron. The carbon had been burnt out by the blast; atmospheric air alone was capable of converting molten cast-iron into malleable iron. He at once turned this accidental discovery to account by devising a furnace through which, when charged with molten pig-iron, air or steam under pressure could be blown.

After a succession of experiments he announced his success at a meeting of the British Association in 1856, when he read a paper on his process. This created a sensation in the scientific world, and ironmasters flocked to secure licences to carry out his process. But the methods employed were not perfect; the licencees gave up the task in disgust, and for a time Bessemer and his process were under a cloud. Two years he laboured in correcting the faults which had manifested themselves in the process, and succeeded in eliminating its weak points. But now manufacturers, never enthusiastic over the invasion of their market by a man who had much steel, and cheap, to offer in place of little, and costly, refused to touch his wares. In self-defence he was compelled to set up on his own account as a steel merchant.

The first evidence of his success was conveyed to his rivals by the information that he was putting on the market high-grade steel at £20 per ton less than theirs. The Bessemer works at Sheffield were established in 1859, and within five years the process was in use throughout the steel-making countries of the world. From his works issued, in vast numbers, guns, boilers, steel plates, rails, girders, crank-shafts, weldless tyres. His invention was quickly proving as important to the users of steel as Arkwright's had been to the manufacturers of cotton. He accumulated a great fortune,

SIR HENRY BESSEMER

was the recipient of many titular distinctions, and to the last retained his inventive faculties unimpaired.

He effected improvements in the manufacture of glass and the polishing of lenses; and his plant for the cutting and polishing of diamonds, if it did not excel those installed at Amsterdam, was a very efficient piece of mechanism. Sir Henry Bessemer died at Denmark Hill on March 15, 1898, leaving his record on the patent rolls of the country in the form of nearly six-score inventions, and a generation incalculably enriched by the chief work of his life—cheap, high-grade steel.

MATTHEW BOULTON

A Pioneer of the Steam Engine

Matthew Boulton was born at Birmingham on September 3, 1728, and long before his memorable partnership with Watt had achieved fame and fortune as an engineer

and inventor. His father, a silver stamper and piercer, admitted the boy, after a grammar school education, into his works at Birmingham. The energy and inventive faculties of the youth helped considerably to extend the business, which was thriving exceedingly when, at the death of his father, in 1759, he himself became proprietor. He invented and perfected a method of making inlaid steel buckles, buttons, watch-chains, etc., and was not a little amused, on exporting these in large quantities to the Continent, to see them reintroduced into England as "the offspring of French ingenuity."

The old works at Snow Hill proving inadequate, Boulton, who had married a lady with a considerable fortune, removed to Soho, then a barren heath, two miles to the north of Birmingham. Here works were established which were destined to become famous throughout Europe.

He invented methods for the reproduction of works of art in metal, and, in order to raise the standard of work which had made "Brummagem" a byword, copied classic examples in the possession of the Royal Family and the great connoisseurs of the period, and sent his agents to scour Europe for prints and drawings which he might reproduce in metal. His patrons soon included the most distinguished people in the land, and the King and Queen would be closeted for hours at a time with him, purchasing his wares and discussing his plans.

The most skilled workmen in Europe made their way to Soho, and it became one of the great show-places of the country, to which all foreigners of leisure went as a matter of course. His own house built there was more like an hotel than a private dwelling, for its hospitality was extended unceasingly to the notable people of other lands, and to artists, inventors, scientists, and philosophers of our own.

A model master, he refused to accept the sons of the wealthy as apprentices, even though heavy premiums were offered, preferring to receive poor, bright boys whom he could train up in his own way to take their place among the foremost craftsmen of Europe. But his vases and statues, his astronomical clocks and telescopes, his inventions for the betterment of coin-making, which led to his carrying out the manufacture of an entire new copper coinage, and the making of machinery for the Mint, while profitable and excellent, were of small importance in comparison with his work in relation to the steam-engine.

He was first brought in touch with Watt through his desire to introduce steam-power into the Soho Works. James Watt had at this time as partner Dr. Roebuck, who, in 1772, owed Boulton £1200, and, failing to meet his liability, assigned to him his share in the patent of the steam-engine at which Watt was working. Long before he met Watt, Boulton had been experimenting with a steam-engine of his own, to enable him to pump water into a reservoir from which to generate power and preserve him against the day of drought. He sent a model of this engine to Benjamin Franklin,

MATTHEW BOULTON

who was then in London, and to Erasmus Darwin, and both were highly interested in it. The American was so confident of its success that he wrote showing Boulton how to ensure smoke consumption, so effecting greater fuel economy, and at the same time preventing the boilers from being sooted up. That was in 1766, but manufacturers have not even yet learned the lesson Franklin sought to inculcate, or our northern towns would not be such grimy infernos as many of them are today.

Watt and Boulton met two or three times at Soho before their partnership, and were mutually attracted. Boulton, after these meetings, ceased experiments with his own model, for, as he wrote, if he went on he would be bound to incorporate in his work the knowledge which he had gained from Watt, a course impossible

to his chivalrous nature. The partnership between the two men was most happy. Watt's fortunes at the time were in great disorder; he was prepared to immerse himself in the duties of a surveyor or engineer in England or to go abroad, as so many of his countrymen were doing. It is probable that but for Boulton we should never have had the steam-engine of Watt. When Roebuck's creditors released that unfortunate man's two-thirds share in the engine patent to Boulton, they did not value it at one farthing.

The history of the eighteen years of stress, anxiety, toil, and vexation which followed upon the association of the two men is well known. The master-mind in the invention was, of course, Watt's, but Boulton was a man of fruitful genius, from whom a multitude of useful suggestions issued. His was the brave heart that supported Watt through all his difficulties, illness, fretfulness, and dejection. He raised the money for the enterprise, and brought himself within hailing distance of ruin for the faith that he had in his partner and in his work. There is no finer chapter in the history of British industry than that which tells the part played by Matthew Boulton in the development of the steam-engine.

At last success came, abundant, brilliant success. The engine began to pay for itself in 1768, but years elapsed before Boulton reaped sufficiently substantial advantage from the invention to clear himself of his grave liabilities. Boulton was an excellent judge of character, and he it was who discovered William Murdock, the inventor of coal-gas. Boulton, who held a commanding position in the scientific life of the nation, and numbered many great thinkers and inventors among his personal friends, died at his Soho residence on August 18, 1809, leaving a world-famous firm to be carried on by his son and the son of his illustrious partner.

LOUIS BRAILLE

Helping the Blind to Read

Louis Braille, the improver of printing for the blind, was born at Coupvray, near Paris, in January, 1809, and when three years of age lost his sight as the result of an accident. He was sent to a school for the blind in Paris, where a method of teaching the sightless to read had already been adopted. This beneficent work had its rise in Paris, where, in 1784, Valentin Haüy first printed raised letters for the blind, and founded the school to which Braille was sent. The Haüy system consisted of ordinary italics, the written form of Roman letters. Successful attempts were made in Great Britain to improve upon the pioneer system, and Gall's letters in relief were adopted in many other lands. Other methods arose, and the art of teaching the blind to read had become widespread when Braille first appeared at school.

He proved a brilliant pupil, and after completing his course was appointed a professor at his school, when only seventeen years of age. Now, Braille was the first to tell the world that all the systems of printing for the blind then in vogue were unsatisfactory from the standpoint of the person restricted to their use. Men gifted with sight had designed the letters for the blind, and, seeing the letters before them, had not realised the difficulties of those to whom the finger-ends must serve as eyes. They had not properly considered this question of touch, by which the blind read. The letter presenting simply a long, smooth outline in relief to the fingers is unsatisfactory.

Braille, who had studied every system in existence, probably drew his inspiration from Gall's serrated type, in which the surface of the letters was made up of minute points, instead of an unbroken line. Even there, however, the attempt was made as closely as possible to follow the outline of the ordinary letter with which the sighted person is familiar. Moreover, by none of the known methods could a blind person write. Before he was twenty Braille published the rudiments of his own system. Another five years passed before he had perfected it. Not until two years after his death was it adopted for use in his old school, though unofficially it was highly approved. And yet it constitutes the greatest boon ever bestowed upon the blind.

The Braille system departs from all attempt to follow the outline of the ordinary letter. Each letter is made up of six dots, and each constitutes an arbitrary outline. The dots are arranged in two parallel columns. The heavy dots indicate the letter, and the remainder of the six dots are lightly indicated to establish the position and significance of the heavy dots. By varying the combinations of the dots, contractions of words and signs for punctuation are secured. The blind readily learn these letters, and read with striking facility. An even greater value attaches to the system, however, in that it may be written as well as printed. The writer is supplied with a frame fitted either with a grooved or

pitted bed. With a blunt awl he punches little dots upon the paper through minute holes in a sliding bar. He writes from left to right. The reader reverses the paper, finds the characters raised in relief on the back, and reads from right to left.

Music can be written by this system without difficulty. Instrumental music is read with one hand, while the other is engaged upon the keys; then the other hand is brought to the manuscript while the notes for the second hand are mastered, and the whole is committed to memory. For vocal music the singer has both hands free to read the notation, and the expert can sing what in a seeing person we should call "at sight." Braille's highly valuable work for blind humanity was crowded into comparatively few years, for he died in Paris in 1852, when only forty-two.

JOSEPH BRAMAH
The Maker of the Hydraulic Press

Joseph Bramah, a self-taught inventor of many useful appliances, was born at Stainborough, near Barnsley, on April 13, 1748, the eldest of the five children of a man who rented a tiny farm. After a short stay at the village school, he was put to work to follow the plough, but was incapacitated by a permanent injury to his right ankle. He had already shown considerable inventive talent. With rough and ready tools, fashioned from scrap iron for him by his friend the village blacksmith, he constructed a plough of sorts. He also made fiddles. One of these was carved from a single block of wood, while another was sold for three guineas, and was still gaily responding to the bow over a hundred years later.

Apprenticed to a carpenter, Bramah became expert in woodcraft, and turned his face towards London as a journeyman, but soon set up in a modest way for himself. Lockmaking had become almost a lost art in England until one Barron took up the subject in 1774. Bramah set himself to improve on Barron, and in due course produced a lock of extreme ingenuity, simplicity, and effectiveness. It was a striking piece of work to spring from the undisciplined brain of a villager, for the lock depends upon the doctrine of combinations or multiplication of numbers into each other. A lock of five slides admits of 3000 variations, while one of eight slides has no fewer than 1,935,360 changes. Bramah offered £200 to anyone who could pick his lock. In spite of many attempts, the reward remained unclaimed until over forty years after the death of the inventor, when, in 1851, an American, after sixteen days' manipulation with a succession of elaborate instruments, won the promised reward. Even so, the lock remains a strong defence against the thief.

A more important invention, however, was the hydraulic press. In this Bramah was assisted, as to a vital particular, by his most brilliant workman, Henry Maudslay, who, setting up in business for himself in later years, had such men as Sir Joseph Whitworth and James Nasmyth among his pupils. Bramah's hydraulic press marked an enormous stride in the creation of hydrostatic plant. Though employed primarily as a packing-press, it was adapted to many uses. Robert Stephenson employed it for hoisting the great tubes of the Britannia Bridge into their beds, and Brunel got the "Great Eastern" off her cradles by the like means. The same principle was employed, but in another form, for Bramah's admirable tool-making machinery, which gave him the foremost place for accuracy and delicacy of finish. The same invention was adapted by him to the fire-engine. He made many improvements in steam-engine building, though he was hopelessly wrong and prejudiced against the invention of Watt.

With his machine tools, and the gradual elimination of hand labour in his various processes, Bramah was far ahead of his times; and it has been said of him that he not only anticipated, but carried out in his own works, the invention of a large number of the most important modern tools. He was regarded, when at the height of his powers, as the finest mechanician in England, and his inventive versatility seemed inexhaustible. For over a century his appliance for printing the number and dates of banknotes has been in use, saving the labour of 100 clerks, to say nothing of the greater accuracy and legibility attained. Bramah died, on December 9, 1814, from the effects of a chill caught in Holt Forest, Hants, where he was superintending the tearing up of 300 giant trees by his infallible hydraulic press.

EDOUARD BRANLY
First Steps Towards Wireless Telegraphy

Professor Edouard Branly, the man of science who made wireless telegraphy possible, was born at Amiens on October 23, 1846. He received his scientific education

at the Ecole Normale, in Paris, where, in 1873, he won his degree of doctor of science by his researches on some problems in electrostatics. In 1882 he took a degree as a medical doctor, being afraid that he would not be able to live by teaching science. He had been a brilliant instructor in science, and he had, like many professors whom the public never hears of, made some fine contributions. A professorship at the Catholic Institute at Paris happily enabled him to give all his energy to scientific work.

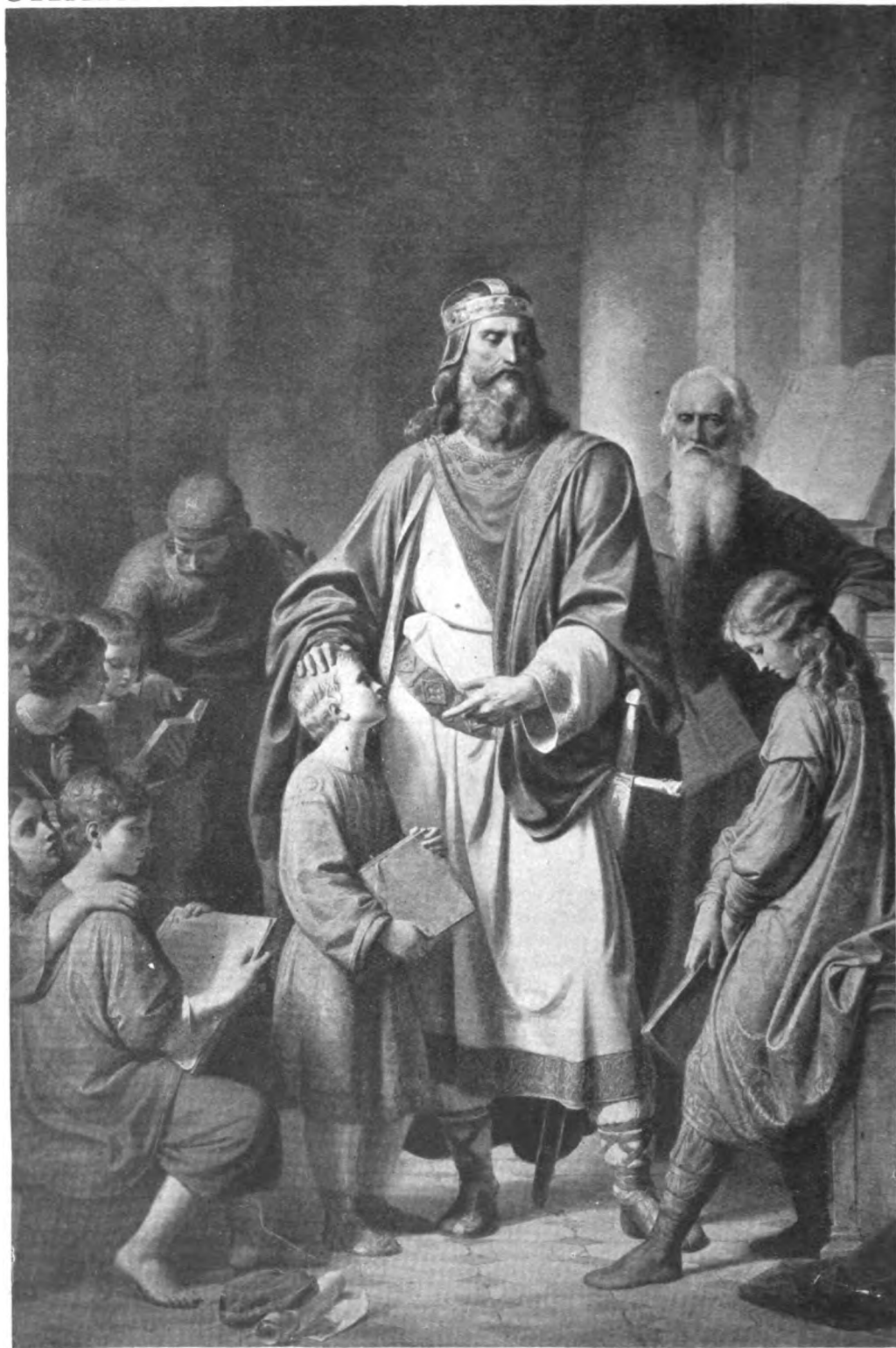
The discovery that has made him one of the best-known of living French men of science was made in 1890, and was quietly announced in a paper entitled "Variations of Electric Conductivity of Disconnected Substances under Diverse Electric Influences." That does not sound very exciting. Indeed, for some time only two men in the world saw its high importance. They were Sir Oliver Lodge and a young student of electricity at Bologna, Guglielmo Marconi. The position was this. Heinrich Hertz had discovered the actual electric waves that Clerk Maxwell had worked out in theory. But Hertz could only detect the invisible waves, created by an electric spark, when they were fairly strong and produced only a few yards away. He used a metal ring with a gap in it, and between the two points of the gap little sparks appeared. Hertz was able to measure the length of some of the wonderful waves by means of his broken ring, but there the matter stopped. From the point of view of pure science, his experiments in confirmation of the mathematical calculations were as amazing as the actual discovery of Neptune in accordance with the calculations of another Cambridge mathematician, Adams. But, from a practical point of view, the knowledge of the existence of electric waves was apparently of no more actual benefit to the human race than was the knowledge of the existence of Neptune.

Professor Branly took the first step to make the waves the servant of man by his discovery that a tube of metal filings became a conductor of an ordinary electric current whenever the filings were affected by an electric wave sent from a distance. By connecting the current from a local battery of the ordinary kind with the tube of filings, the electric waves were made to reveal their presence. When there were no electric waves, the filings allowed no current to pass from the battery. When the subtle electric radiations were influencing the filings, the current passed.

Such was the famous coherer that first Sir Oliver Lodge, and then Mr. G. Marconi, adopted and improved. No doubt if Professor Branly had patented his discovery, and set to work at once on the commercial development of wireless telegraphy, he would have gained something like a monopoly and a fortune. But he quietly gave his coherer to the world, as he did his discovery of electrostatic phenomena in batteries, positive discharge of gases, violet rays, and incandescent bodies.

When Professor Branly became interested in the technical difficulties of wireless telegraphy, and left awhile his study of purely scentific problems, he brought out many inventions of importance. He has introduced, among other apparatus, new radio-conductors with tempered and polished steel contacts for electric-wave telegraphy, and new independent distributing devices for producing mechanical effects at a distance without wires. About six years ago he constructed a safety apparatus, independent of all syntonisation, to prevent the action of accidental sparks in his mechanical effects at a distance. He has also done much towards solving the problem of maintaining secrecy of communication between transmitting and receiving stations.

Still later, the inventor of the coherer excited general attention by his progress in the transmission of mechanical effects. He has shown that, without any possible interference from electrical disturbances in the atmosphere, he can with his electric waves start and regulate machinery, fire big guns, explode mines, light the lamps in lighthouses, and perform other actions at a great distance. He controls these mechanical devices over a range of some hundreds of miles, and it has been reported that he has experimented with a system of vision at a distance. This is the last and most difficult problem in the science of electrical transmission.

Some measure of success has already been obtained by a Russian man of science by means of an arrangement of mirrors throwing reflections on to a piece of selenium, which has the curious property of altering its resistance to the passage of an electric current, according to the amount of light or shadow it receives. If Professor Branly helps forward the science of tele-vision, as he did the science of electric-wave telegraphy, the result will be marvellous. But the obstacles in the way seem great.

CHARLEMAGNE, THE PATRON OF ALCUIN'S EDUCATIONAL MOVEMENT, VISITING A SCHOOL

CONTINUED ON PAGE 4565

PIONEERS

ALCUIN

Founder of University Education in Europe

ALCUIN, or, in English, Ealhwine, was the Englishman who had the widest influence in the world in the days of Charlemagne. From Charlemagne sprang the university movement on the Continent, and Alcuin was the educational inspirer of Charlemagne. When learning had almost perished on the Continent, under the wave of barbarism that swept away the Roman Empire, it found a sanctuary in the North of England, through monkish scholars who arrived by way of Ireland and the West of Scotland, and in the middle of the eighth century York was the greatest educational centre in Christendom, and had the most valuable library. Here, in 735, Alcuin was born. Educated in the cloister school, he became first one of its teachers, and, at the age of forty-three, its master, with a repute far beyond his native land. Indeed, he was known personally abroad, for we have evidence that he had visited Paris and met Charlemagne before, in 781, he journeyed on a mission to Rome. Returning, at Parma he again met Charlemagne, who was so delighted with his personality and aims that he invited the Englishman to come to his Court at Aix-la-Chapelle, and there establish a palace school. Alcuin complied, and from that nucleus of patronised learning mediæval education grew, with its great Universities of Paris, Tours, etc.

Alcuin's motive was religious. In his own words, he wished "so to teach children grammar and the doctrines of philosophy that, ascending the steps of wisdom, they may reach the summit, which is evangelical perfection." His ambition was to re-establish education as it existed in the days of St. Augustine; and to this end, though his instincts were conservative, and he had a distrust of the old-world poetry, he promoted learning on classical lines, taking the "seven liberals arts" of grammar, rhetoric, logic, arithmetic, geometry, music, and astronomy as his curriculum, thus following the example of the school he had left at York.

Charlemagne himself, his four sons, and two daughters became pupils of the English teacher, and he helped Alcuin to spread the movement for education in and through the monasteries. Alcuin wished "to make the library the armoury of the monk." But presently he tired of the roughness of the Frankish Court, whereupon Charlemagne, who continued to be his admiring friend, made him, in 796, abbot of the great monastery at Tours—a princely domain. Here Alcuin continued his educational work until Tours became the centre of French culture and of influence in the Church, and had gathered a library that vied with that at York. At Tours, in 804, this energetic and captivating pioneer of education died.

The special feature of the work of Alcuin was that he not only stimulated education in the religious houses, but extended it to the laity. The parish priests were encouraged to teach; the cathedral schools grew into a position that would now be described as secondary; and the palace school was the forerunner of the university foundations. Though we look back now with wonder at the narrowness of the scholasticism of the mediæval age, its establishment was a great advance on the rough and iconoclastic ignorance of the ruling class that preceded the liberal movement of Charlemagne; and the change was largely due to Alcuin.

A considerable amount of writing by Alcuin has been preserved, though some is of doubtful authenticity, and none of it is of a character to sustain a literary reputation. As Dr. Rhodes James has

said, "It is the intellectual stimulus which he imparted and the long line of scholars which owed to him its existence that form his true monument."

The one great Englishman who lived between Bede and Alfred may fairly be said to have founded the Continental education which survived when Danish barbarism had swept away the venerable culture of Yorkshire and Durham.

BENJAMIN NICHOLAS APPERT
The Creative Philosopher of Education in France

Benjamin Nicholas Marie Appert was born in Paris on September 10, 1797. With imagination and sympathy uncommon in his era, he early realised the grievous handicap under which the uneducated poor laboured. It was after Napoleon had beaten Prussia prostrate that Fichte preached his crusade for national regeneration through the medium of education. It was after the eagles of France had been trodden in the dust at Waterloo that Appert, then only eighteen years of age, began his beneficent campaign for the intellectual uplifting of the proletariat of France. He invented a new scheme of mutual instruction, and persuaded the Government that her conscript soldiers would wield the sword not less ably if permitted in their leisure to master the mystery of the pen. Practically unaided, he succeeded in carrying his point, and was granted free admittance to the military schools. He had a national army for his pupils; and in three years, or thereabouts, by the scheme of mutual instruction which he had evolved, he succeeded in educating 100,000 French soldiers to read and write. The soldier of today is the citizen of yesterday and tomorrow. Appert's soldiers carried their reading and writing into the remotest corners of France, and a new era of learning had dawned for the land.

The intellectual elevation of the French masses may be said to date from the efforts of this one creative philosopher. But he did not rest content with teaching soldiers their letters. He carried his lantern of learning into the gaols, holding that the fallen might be reclaimed by teaching. Here he fell foul of the authorities. He was accused, not without reason, of having been privy to the escape of two prisoners. It was but a political offence with which they were charged, the equivalent of the absurd *lèse-majesté* of our own time, and Appert would watch their flight with equanimity. In the result he himself was imprisoned. It was all for the good. John Howard, the English prison reformer, had lain nine years in his grave when Appert was born; the Frenchman was inspired by personal experience of the horrors of prison life to take up the cause of the victim of the gaol system. To this end, upon being liberated, he made a tour of the principal Continental prisons and galleys, and wrote voluminously and with power upon his investigations.

In his later years he became attached to the Court, and was able to carry out extensive reforms for the benefit of the poor, and wrote a history of such part of the reign of Louis Philippe as he had witnessed. He died in the year 1847.

HERTHA AYRTON
The Foremost English Woman of Science

Hertha Ayrton, our foremost Englishwoman in science, was born, of Jewish parents, at Portsea, in a year which her biographers fail to record. Left fatherless at an early age, she quitted school at sixteen to earn her own livelihood as a teacher, but later was enabled to enter Girton, at that time a relatively small college, where she achieved high distinction in mathematics. While there she invented an instrument called the sphygmograph, which accurately registers the beats of the pulse; but finding, too late, that she had been in some measure anticipated, she abandoned this line of research, albeit, in 1912, a development from another hand of the same idea was received with considerable respect in the scientific world.

On quitting Girton, Mrs. Ayrton returned to teaching, and in her spare time contrived an admirable machine, a line-divider, which instantly divides a line into any desired number of equal parts. Still anxious to extend her own studies, she entered herself, in 1884, at the City and Guilds of London Technical College, Finsbury, where that fine character Edward Nugent Ayrton (1847-1908), after a romantic and brilliant career in science, had been Professor of Applied Physics from 1879.

The young girl, who had just previously entered with avidity upon the study of electricity, found in Ayrton the one man calculated to fire her genius for research, and he found in her the woman designed by Nature, as it were, to be his helpmeet. Professor and pupil became man and wife, and the union was as happy in its results as that of the Curies. In 1893 Ayrton was due to deliver a lecture in Chicago before the Electrical Congress on the electric arc. By a strange fatality the paper was

destroyed by fire. Mrs. Ayrton set to work to repair the damage, and succeeded in preparing an abstract of the points which the original had contained. Then she took up the work at the point where he had left it, continued the experiments, and sent the reports of her results out to America to him by mail. In the end Mrs. Ayrton herself carried on investigations, and made the subject her own.

Important results have followed. Mr. Duddell, F.R.S., has since discovered the musical arc, and applied it, with highly important effect, to wireless telegraphy. When he took out his patent he was still one of Ayrton's students at the Central

HERTHA AYRTON
Photograph by Russell & Sons

Technical College, but the way for pupil and professor had been prepared by the patient labours of the lady in the background. The result of her experiments and a development of her theories was published in the technical Press, and afterwards in volume form, and her reputation as a scientific discoverer of a high order was forthwith established. She read papers at the British Association meetings of 1895 and two subsequent years, and was elected the only woman member of the Institution of British Electrical Engineers. The Royal Society awarded her its Hughes Medal, but was advised that it had not power to admit her to a Fellowship.

This latter distinction, however, was the outcome of another branch of Mrs. Ayrton's studies. While at Margate, nursing her husband, she was drawn to a consideration of the sand-ripples on the shore. The sight with which every day-tripper is familiar had a new message for this remarkable woman, and she devoted herself by observation and experiment to discovering how these ripples are caused. She created a miniature seashore of her own, a tank in which she could not only look down upon her sands, but examine them in profile. The purpose of her tests and the conclusions reached were embodied in a remarkable paper which has set many students to work. She explains her investigations in the following terms:

"Sand-ripples may seem at first a small matter, but any explanation involves all the principles underlying the motion of water and of bodies oscillating in the water. One's aim in research of this character is to find out what underlies certain phenomena, and I feel sure that in the end it will be of practical value in dealing with coast erosion or quicksands. At present our knowledge of the motion of water is slight. I make the suggestion that the Goodwin Sands are really large ripples. There is a narrow spit of land near the Goodwins, and it seems possible that if the configuration of the shore could be altered, and the trend of the water changed, the Goodwins might disappear."

Much work remains to be done in the field of inquiry which Mrs. Ayrton has thus opened up. The subject is one of importance, not only as to our coasts, but as to every navigable river. The town of Preston has sunk between two and three millions sterling on its docks, and the greater part has been expended over the perennial enemy, sand, which, carried in by high tides, silts up the channel. Mrs. Ayrton's work in regard to the electric arc, too, possesses high economic importance as well as scientific interest, for to her belongs the credit for discovering, by many refined and ingenious experiments how in powerful searchlights and other arcs the light may be confined to its proper function, and the carbons made to burn equally, without roaring or waste.

ROBERT BAKEWELL

Increasing the Food Resources of Mankind

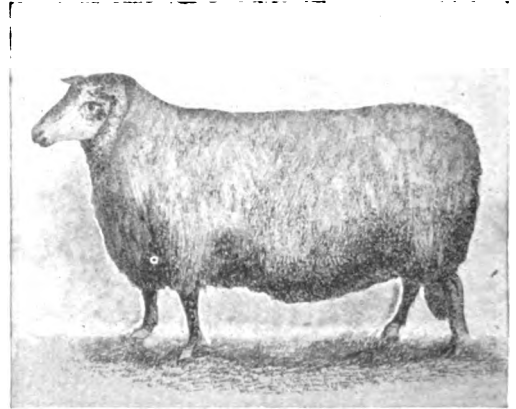
Robert Bakewell, the son of a Leicestershire farmer, was born at Dishley, in 1725 Few persons remember his name but he was

one of the truly great benefactors of mankind. Brought up on his father's farm of 440 acres, he was the first man to see that the sheep, cattle, and working horses of the eighteenth century were useless for modern purposes. They were ill-kept, cruelly underfed, and allowed to breed anyhow. Bakewell resolved to make stock-breeding and stock-keeping a science; and for some time he travelled through the West of England and other parts of the country, visiting farms and closely studying the qualities of sheep and cattle and horses, and observing the various ways of feeding and tending them. He was also a quiet, alert student of the different systems of husbandry.

At the age of thirty, he was able to put into practice the new and revolutionary ideas that he had slowly formed. His father grew too ill to look after the farm, and the management of it fell into his hands. Five years afterwards his father died, and he became the actual tenant of the lands. He aimed at providing the growing industrial population with the rarest of all luxuries—good, fresh meat. Half-starved sheep, bred merely for wool, lean, overworked oxen, and exhausted milch cows were not sufficient to maintain the strength of a people rapidly drifting from the active life of the open fields into industrial occupations. Bakewell tried to produce a new breed of sheep and oxen that would afford excellent, abundant, and cheap food. He made a collection of skeletons and preserved carcases of animals, and he studied them until he found where breeds differed in amount of flesh. He engaged in long feeding experiments, and invented new devices for the comfort and health of his animals. Many of the present humane ideas as to the treatment of animals were anticipated by him.

By his science in the selection and mating of his flock, he succeeded in producing the new Leicestershire breed of sheep, which quickly established itself throughout the temperate world, practically doubling the weight of meat on each animal. Bakewell also created a novel variety of cattle, known as the Dishley long-horns. They were curiously small, inclined to fatness, and of high value to graziers. Then, turning to horses, he obtained from his well-planned experiments a new breed of black horses that were remarkably strong in harness on the farm and very useful in the Army.

In order to bring off experiments in breeding that he could not himself afford, Bakewell used to let his rams out on hire, and after a few years he made several thousand pounds annually by this means. One remarkable ram, known as "Two-Pounder," earned him as much as 1200 guineas in a single year. In 1785 King George III. arranged for the famous stock-breeder to bring a splendid black horse he had created to St. James's Palace for inspection, and for some months it was exhibited in London.

Bakewell was a pioneer in every department of farming, as original in his methods of feeding and housing stock as he was in breeding new varieties. By irrigating his grasslands, he secured four crops of grass in a year. His farm was visited by persons of all ranks of society. There was no inn at hand, and Bakewell hospitably entertained all comers. He had a gospel to preach, and a gospel that has grown of greater importance with the development of the industrial populations of the world. His direct aim was to increase the food resources of mankind, but the methods of breeding which he worked out were an instrument for improving any desirable

ONE OF ROBERT BAKEWELL'S SHEEP

qualities in animals. Great as were the profits from his experiments, the cost was still greater, and he went bankrupt in 1776. He died on October 1, 1795, at the age of seventy, and was buried at Dishley.

ANDREW BELL

A Founder of Day Schools

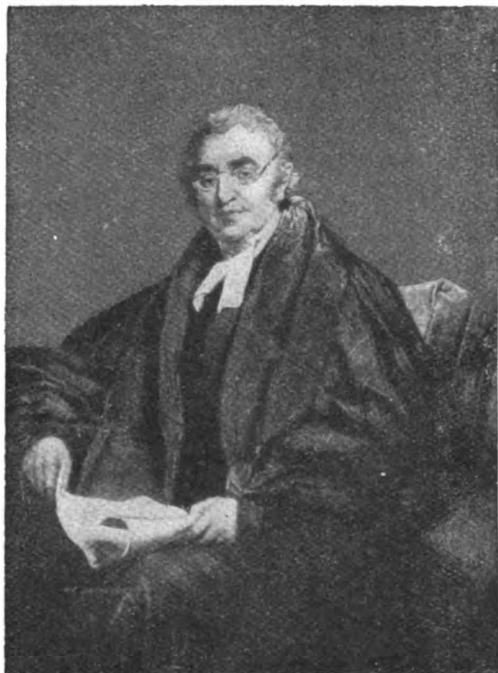
Dr. Andrew Bell, the founder of "the National Society for Promoting the Education of the Poor in the Principles of the Established Church throughout England and Wales," and one of the popularisers of the monitorial system of teaching, was born at St. Andrews, March 27, 1753, and educated at the university of his native city. After living seven years in Virginia as a

tutor, Bell was ordained, and went out to India as an Army chaplain. Soon he held simultaneously eight clerical appointments. One of the duties he took on himself was the organisation of the Military Orphan School in Madras. He had observed how Indian children teach each other in their open-air schools, and, applying the method in the orphan school, he taught there by means of the elder children with success.

When he returned to England, pensioned by the East India Company, he wrote a pamphlet on his monitorial system, and published it in 1797, under the title "An Experiment in Education Suggesting a System by which a School or Family May Teach Itself Under the Superintendence of the Master or Parent." The experiment attracted little attention, though a few schools adopted the system.

Independently of Bell, an undenominational school was being conducted a few years later in South London by Joseph Lancaster, who, in 1804, on seeing Bell's pamphlet, exchanged experiences with its author. Lancaster's system spread rapidly, but financially was unsuccessful, and in 1808 he was supported by a body of undenominational educationalists, chiefly Quakers, who, however, believed in religious education. They called themselves the Royal Lancasterian Institution for the Education of the Poor, and later the British and Foreign School Society. As the undenominational Lancasterian, or British, schools began to multiply rapidly, the Church of England began operations on its own account in 1811, and, adopting Bell's plan of teaching, formed what is now called the National Society, with the full title mentioned above. Bell was appointed its organising superintendent. The "National" schools of England are the schools affiliated with this society.

Bell, who was given the degree of D.D. by St. Andrews University, became prebendary of Lichfield Cathedral, and later of Westminster. He died January 27, 1832, and was buried in the Abbey. A notable pluralist, he left a large fortune, of which £120,000 was devoted to education.

There has been keen competition for the honour of founding the monitorial system of teaching. The fact is that Bell first proposed it; and Lancaster, independently, brought it into widespread use, Bell, later, following suit, under powerful ecclesiastical support. But the idea had been in many minds, and, to some extent, had been brought into use by Pestalozzi before Lancaster made it a popular success. Though it is now rejected universally by scientific educationists, it served a valuable purpose in its day. It enabled schools to be started, and to be conducted cheaply, where there was no adequate supply of adult teachers; and it accustomed the people to regard education as necessary and available. Bell's plan was to teach the elder scholars early in the day what they might teach the rest of the scholars later. Such teaching was, necessarily, done by "mass methods," as a kind of mechanical

DR. ANDREW BELL
Photograph by Rodger

educational drill; and it necessitated strict discipline. Individual initiative on the part of the scholar was impossible. But it was cheap when cheapness was the only possibility; and the elaborateness of the necessary organisation led to the establishment of training colleges for teachers, and to the development of a system which, after a hundred years of jarring experiment, seems likely to become truly national.

EDWARD BELLAMY

A Dreamer of Social Reconstruction

Edward Bellamy, the last writer who popularised an ideal State—a Communistic Utopia—was born on March 25, 1853, at Chicopee Falls, in the State of Massachusetts. He studied as a young man both in the States and Germany, and, returning home,

was admitted to the Bar in 1871, but almost at once was drawn aside into journalism, and began to edit a newspaper in his native district. Later he became an editorial writer on one of the most responsible of American newspapers, the "New York Evening Post." His early incidental writing took the form of novelettes, of which he published three with fair success. It was not, however, till he gave the world "Looking Backward, 2000-1877," in 1878, that he became widely known. The book gained immediate and enormous popularity, passing through many editions in all English-speaking lands, and securing translation into the principal foreign languages.

At first it was accepted as a romance pure and simple by people who read only for passing interest; but Bellamy had put into it his deeply felt convictions, and was in dead earnest in believing that his suggested reorganisation of society was a possibility, so he devoted himself to the propagation of his ideas in the Press and on the platform. But his book lost as politics the hold it had gained as fiction. A sequel, entitled "Equality," proved unsuccessful, and a society formed to give the impetus of party to the author's ideas has not lived. Bellamy died at his birthplace on May 22, 1898.

He was a brilliant, optimistic, man, who thought social changes might be made by a *coup de main* which can only be brought about in the most gradual way. Whatever may be thought of Bellamy's ideal State, the attempt to realise it was clearly ill-timed. Much of the organisation of society described in "Looking Backward" was adapted from Sir Thomas More's "Utopia" to fit modern conditions.

The introduction was ingeniously arranged—a great improvement on the customary traveller from unknown shores who describes his experiences. Bellamy imagined a rich Bostonian of the year 1877, who to overcome insomnia built himself an underground retreat in which, when his ailment becomes specially troublesome, he was soothed to sleep by a mesmeric practitioner. While lying thus in a state of trance the house was burnt down, the secret chamber remaining undiscovered. The owner was supposed to have perished in the flames with his confidential servant, and the mesmerist had left the country. In the year 2000 the vault is accidentally disclosed, and the sleeper, recovering from his trance, finds himself in a new world, but as youthful as ever. He thinks it is next morning, but really it is 117 years later.

The substantial part of the book—lightened by old and new love experiences—consists of the discovery by the awakened man how the social problems of the end of the nineteenth century have been solved before the coming of the twenty-first century. In the interval combinations of capital and combinations of labour have become so complete on each side that a coalescence of all industry into a single State has been imperative, and the working of this ideal commune is described, so as to meet the various objections which defenders of individualism and the unlimited accumulation of private property would advance today. Poverty is abolished. Each member of the community is trained to do, with honour, the work for which he is suited—the doing of other work being less agreeable to him—and the rewards of industry and endeavour are such as each can most freely enjoy. Science has made enormous advances, and most of the evils of nineteenth century civilisation have disappeared, and, indeed, are already regarded as almost incredible records of a barbarism that has become well-nigh unthinkable.

The interest of Bellamy's imaginative social construction is that it uses the materials which the optimistic philosophers of the past have accumulated, and cleverly adapts them to the requirements of today, and the problems that have arisen most recently from the onward passage of social evolution. It therefore has a much greater sense of reality, and appearance of completeness, than such ideal forecasts as More's "Utopia."

GEORGE BIRKBECK

The Founder of Mechanics' Institutes

George Birkbeck, the father of popular scientific education in Great Britain, was born at Settle, Yorkshire, on January 10, 1776. The son of a banker, he studied medicine, and took his degree of M.D. at Edinburgh when twenty-two years of age. Among his college friends were Brougham, Jeffrey, and others destined to achieve fame. Birkbeck distinguished himself as a student, and, in the year following the completion of his medical course, was appointed Professor of Natural Philosophy at the Andersonian University, Glasgow, in succession to Dr. Garnett. In later life Birkbeck became a highly successful physician, and, especially after his removal to London, had a large and lucrative practice.

But it is as a pioneer in the education of the working classes that Birkbeck's

name is presented to posterity. Birkbeck witnessed the beginning of great industrial developments, the launching of many new trades, as steam-power began to open up fresh vistas to the toilers of the land. But everywhere the cry from manufacturers arose—the cry for skilled workmen. Watt, while in Scotland, vowed that there never were such incompetent fellows as his countrymen; and Boulton told him that no Scotsman who went to him seeking employment as an engineer was successful. Of course, Murdock was a brilliant exception. The rest, Boulton said, proved after a time to be good clerks or accountants—

GEORGE BIRKBECK

anything but engineers. There was a sudden call for a new race of artisans, of men skilled in work to which they had never been accustomed.

We have witnessed a similar thing since 1896, when motor-cars became legalised in England. We have suddenly had to call for scores of thousands of motor-engineers and driver-mechanics. We have got the engineers, but not the mechanics. Not one chauffeur in a score is a really competent mechanic; scarcely a single driver of taxi-cabs in London is a mechanic. The companies' men, even if their trouble be so insignificant as a punctured tyre, have to telephone to headquarters for assistance. They can start their engines and steer their cars when running—that and nothing more.

The case was the same in regard to engineering as a whole in Birkbeck's day. A new calling had suddenly come into the world, but there were not workmen enough to fill the positions vacant, and trade languished for skilled hands, while important inventions were held up through the abominably bad work of the men who were installed. Birkbeck was the first man not actually engaged in industry to recognise this weakness. He set himself to apply a local remedy by establishing classes and lectures to working men. He began his course simply as a series of classes at the university. He left for London in 1804, but the work that he had started in Glasgow went on and flourished, and out of it grew the first Mechanics' Institution.

Encouraged by the success of the movement which had developed from his old classes, Birkbeck, now a busy physician in the metropolis, consented to establish similar classes in London. At a cost of £3700 he built the first lecture-room, delivered the inaugural address, and assumed the leadership of the campaign against ignorance. Lord Brougham, who was one of the trustees of the institution, loyally assisted him. Like all other popular movements directed at leaving the world a little better than their originators found it, the Birkbeck scheme was the butt of cheap sneers and petty ridicule, but it captivated the imagination of the thoughtful. The movement aimed at providing, at infinitesimal cost to the student, instruction in elementary and technical branches of knowledge, by means of libraries, reading-rooms, lectures, and demonstrations. The London establishment was called the Birkbeck Institution, out of compliment to its founder, but it was as Mechanics' Institutions that its many copies spread about the country.

The first generation of members were taught their trades as mechanics, but later the scope was widened to embrace the elements of a higher education. Here, by private effort, were laid the foundations of our national system of popular scientific education. The movement has grown considerably within recent years, and from the old institutions have arisen new branches. Some of them, the working men's clubs, are not an unmixed blessing, as their drink-bills testify; others, while retaining the name of Mechanics' Institution, have come into the possession of the upper and middle classes of provincial towns, to the exclusion

of the people in whose interests they are supposed to have been founded. But the general effect of the movement upon the country has been enormously for good, and the name of Birkbeck is honoured as that of a national benefactor.

He found time, in spite of many claims upon his leisure, to extend a helping hand to all movements that tended to the educational uplifting of his generation. Thus he assisted at the establishment of London University College; he fought unweariedly for the repeal of the taxes upon knowledge; and by his lectures, by his generous gifts of money, and by his unstinted labours in many directions fought a good fight for a nobler and happier and better educated England. He died on December 1, 1841.

SIR GILBERT BLANE
The Great Doctor of Armies and Navies

Sir Gilbert Blane, the saviour of sailors, was a Scotsman, born at Blanefield, in Ayrshire, on August 29, 1749. He was intended for the Church, and sent to Edinburgh University at the age of fourteen. But, happily, he was attracted to the study of medicine, and under Dr. Cullen—who had already turned out, in Joseph Black, a physician who was revolutionising chemical science—Blane became a doctor with a fine, scientific mind. Through Cullen's recommendations, the young man won the position of private physician to Admiral Rodney, and in 1779 sailed with him on the famous expedition to the West Indies. Rodney, perhaps, did not know much about the medical art, but he could tell the worth of a man; and Blane's great courage in coming forward at a critical emergency, and conveying, under fire, an important order to the officers at the guns, won the admiration of the admiral, who appointed the young Scottish doctor to the high position of physician of the fleet.

Blane retained this post until he returned to England at the end of the war. He displayed conspicuous bravery, was under fire in several engagements, and wrote an account of the great victory that Rodney won over a more powerful French fleet, by means of the new manœuvre of breaking the enemy's line of battle and enveloping one of the broken halves with all the smaller English force. But it was not Blane's warlike activities at sea that made him one of the great benefactors of the human race and mariners of all nations. He took a large view of his office of physician of the fleet; and though man of the older medical men under him must have chafed at his appointment, and looked at it as a piece of jobbery, the young Scotsman profited by his fine opportunities to make a scientific study of the common disablements of seamen. His aim was, as he said, to " better the condition of a class of men who are the bulwarks of the State." For three years he had detailed monthly reports sent to him of all classes of sickness on the fleet of from thirty to forty warships under his medical charge, and in the treatment he worked out he sought for prevention rather than cure.

Fevers and scurvy were the two chief plagues of a seaman's life. The first he considered were to be prevented by cleanliness and fresh air, and in his recommendations for keeping ships well scrubbed there was something of a practical anticipation of modern antiseptic methods. He knew, of course, nothing about disease germs, but he correctly concluded from his study of the monthly sick reports, and his observations on the conditions of the ships with the great and the least sick-lists, that the more often the men were set to scrub the ship clean, the less frequently they were attacked by fever. Some people, however, were at this time inclined to think that the hard labours of a crew made them greatly liable to scurvy. This was the most terrible scourge of a sailor's life. When Anson circumnavigated the earth, more than four-fifths of his crew were struck down by it. Our naval expedition to Carthagena failed through an outbreak of it; so did two earlier operations. At the time when Blane was trying to cure his fleet, the garrison of Gibraltar, besieged for three years, were so ill of the scurvy that their eyesight was weakened, and they could not aim rightly.

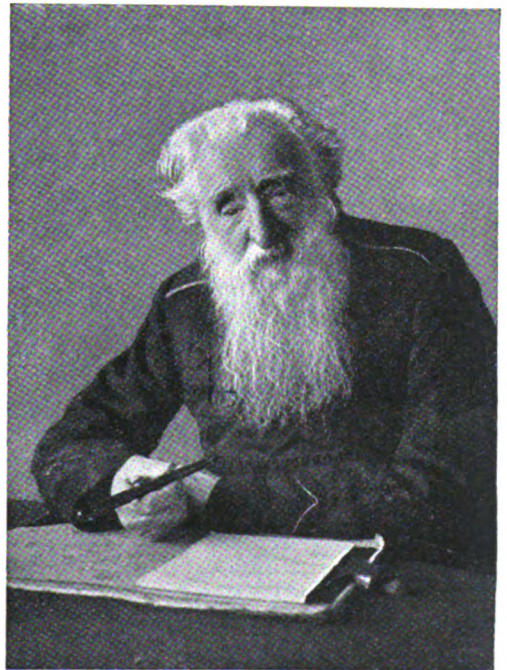
The disease came on slowly, with loss of colour and strength. In a week or more the blood began to ooze under the skin, and there were swellings at various parts of the body. Death occurred after several weeks of pain, from loss of blood or exhaustion. Dr. James Lind had pointed out that lemon-juice was a remedy, and sailors in the South Seas had found relief in the consumption of cocoa-nuts. Lind, however, had not been able to get men to put his idea generally into practice. Blane happily tested it on the first occasion that offered, and found that scurvy was produced by a stagnation of the circulatory system, and that lemon-juice quickly restored the blood and lymph to a healthy condition. Until Sir Almroth Wright

recently found how to thin and quicken the flow of blood by the use of preparations of lemon-juice, and then, when needed in special diseases, thicken and retard the flow by another medicine, Blane's old observations on the stagnation of the humours in scurvy, and the part played by lemon-juice in removing the stagnation, remained one of the most useful discoveries made in connection with the blood.

By combining the regular serving of lemon-juice to the fleet, and carrying out his new sanitary reforms on all the ships under his care, Blane produced some remarkable results. As Admiral Rodney wrote at the time: "To his knowledge and attention it was owing that the British fleet was, notwithstanding their excessive fatigue and constant service, in a condition always to attack and defeat the public enemy. In my own ship, the 'Formidable,' out of 900 men, not one man was buried in six months." The effect of this, and of Blane's own memorials to the Admiralty on lemon-juice and sanitation, was that, in 1795, regulations were issued for the universal use of lemons in the Navy. The merchant marine of the whole civilised world gradually adopted the practice, and the commonest and most dreadful of sailors' diseases became at last practically an unknown, legendary thing. The general success that attended the measures of reform he brought about made Blane the most popular and powerful doctor in the kingdom. He ruled over the medical affairs of the Army as well as the Navy. Emperors, kings, and presidents of republics sought his help. He died June 26, 1834.

WILLIAM BOOTH

The Science of Social Regeneration

William Booth, founder and "General" of the Salvation Army, was born at Nottingham on April 10, 1829, and was educated at a private school. The son of Church of England parents, at thirteen years of age he revealed a precocious independence of thought by renouncing the Church of his family, and allying himself with the Wesleyan Methodist Connexion, whose services, he said, were more interesting and appealing than those of the Established Church. His religious convictions did not become quickened, however, until two years later, when he was "converted" by the preachings of an American revivalist. Fifty years later the General wrote of that event: "The hour, the place, and many other particulars of this glorious transaction are indelibly recorded on my memory." Booth and a few young friends, fired with a zeal matching his own, began to hold services on their own account, services which were in almost every particular the prototype of those which have since become an established feature of Salvation Army procedure. The little band acted nominally as a sort of guerilla ally of the forces of the chapel with which it was associated, but when at seventeen Booth was asked by his pastor to become a local preacher, and enter his name upon the connexion "plan," he refused, pleading his youth, but really recognising that greater opportunities lay in the path that he had chosen. Later he

WILLIAM BOOTH

did yield to pressure, to find himself, as he said, "hooked into the ordinary rut, and put on to sermon-making and preaching." But he was not born permanently to serve under the orders of others, and, relinquishing his mission, he reached London, and for three years was in business,

At the end of that time he renewed in the metropolis the open-air services which he had begun at Nottingham. But he now combined mission work with study, and, surprising though it seems today, he became a Wesleyan minister, and preached with such effect that his Church appointed him evangelist to the whole connexion, in

which capacity he conducted services in the chief towns of the country. He seems to have been rather a thorn in the side of his Church, however, for he was eventually bidden to return to regular duties, and, with unusual compliance, settled down to a pastorate at Gateshead. He had married a gifted, helpful woman, and for a brief period was at peace. At the end of four years he was ordered to move on. His congregation desired that he should remain, and he desired the same thing. As his chiefs were inexorable, he resigned his position in the Wesleyan Church, and became an independent itinerant preacher, backed by the efforts of his wife, who was as forceful and a more cultured speaker than himself.

At first they preached in chapels which remained open to them, first holding open-air services, and leading their congregation in from the highways and byways. But this plan presently failed, and the open-air service became the established feature. After campaigns in many directions, Booth established himself in London, opening, in premises which had been a disreputable Whitechapel public-house, the "East London Christian Revival Society." That was in 1865, and from that mission grew the Salvation Army. The organisation had always a semi-military character, and this was enhanced, on the suggestion of Mrs. Booth, by putting their adherents into uniform. The final name was the result of what Booth afterwards considered an inspiration. He was drafting the annual report of his mission, and was writing, "The Christian Mission is a Volunteer Army." Then, he afterwards used to say, "Something flashed across me. I scratched out the word 'Volunteer' and substituted 'Salvation.' It was a memorable inspiration." The movement spread like a fire through the land, and beyond it. The army sorght primarily the souls of men, but incidentally they saved bodies, too.

In 1890 the famous "Darkest England" scheme was launched. The idea was the General's, but it was clothed in the brilliant language of the late W. T. Stead—which fact, by the way, was not known until both men had passed away. The scheme was one of the greatest projects for social reform ever presented to the country by an unofficial organisation. It was a comprehensive plan to carry material weal as well as spiritual salvation to "the submerged tenth." It embraced labour colonies at home, emigration to our oversea possessions, rescue homes for the fallen of both sexes, adults and children; food for the hungry, clothes and shelter for the homeless. Booth raised £100,000, and was able to carry out a scheme which, while short of his ambitions, was by far the most effective attempt at a great social regeneration ever witnessed in Great Britain.

Booth worked unweariedly to the end of his life. Always a great traveller, he hastened his steps as the end approached, and by the fastest trains, fastest steamers, and the fastest motor-cars sped from shire to shire, from country to country, from continent to continent. Persecution and obloquy, which had so long followed the army, all died away during the reign of King Edward, who, with Queen Alexandra, took a deep interest in the work of the unwearying evangelist, and caused the Salvation Army to be officially represented at his Coronation. University and other honours were showered upon him, his journeys were triumphal progresses, with formal complimentary receptions awaiting him on his way through cities where at one time the mob used to stone him.

Towards the close of his days his eyesight was severely affected, and finally he became totally blind. To the last he never lost control, but thrilled his army with his old-time fervour and energy, and, so far as was possible, prepared the way for the still greater triumph of his successor, his son, Mr., now "General," Bramwell Booth. William Booth died on August 20, 1912, and it is no exaggeration to say that the whole civilised world mourned his loss.

He left behind a remarkable organisation. The Salvation Army at his death comprised nearly 21,000 officers, cadets, and employees, and 9130 corps and outposts, distributed over fifty-nine countries. Among the philanthropic and social institutions connected with it are 117 rescue homes, 25 maternity hospitals, 43 children's homes, 18 prison-gate homes, 259 shelters and cheap food depots for the homeless, 184 workshops and factories, 51 labour bureaus, and 22 farms. The army has some 54,000 local officers, and weekly conducts, all over the world, upwards of 32,000 open-air meetings, and a still larger number in the innumerable halls reserved to its use.

JOHANN FRIEDRICH BÖTTGER

The First Maker of Porcelain in Europe

Johann Friedrich Böttger, inventor of the famous Meissen, or Dresden, porcelain, was born at Schleiz, in Reuss, in 1682. At the age of twelve he was apprenticed to an apothe-

cary in Berlin, when alchemy was the craze of every ingenious mind. Naturally, the lad turned his attention to the subject, and he succeeded in deceiving his master into the belief that he had converted base metal into gold. News of the pretended invention spread, and the shop was crowded with the credulous to get a glimpse of the young "gold cook." The story reached the ears of Frederick I. of Prussia, who sent for the inventor, and, being shown gold which Böttger was alleged to have made, resolved to immure him in a fortress, and employ him to make gold for the furtherance of the royal military schemes. Böttger suspected his patron. and, escaping across the border into Saxony, flung himself, with his story of gold-making, at the feet of the Elector of Saxony, Augustus the Strong, King of Poland. Augustus, who was needing money as badly as Frederick, received the young alchemist with open arms; and though a battalion of Prussian Grenadiers appeared before the palace demanding the surrender of the young rascal, he was not given up. Having to depart for Poland, he demanded his secret of Böttger, who gave him a phial of liquid which, he declared, converted liquid metal into gold. Arrived at his destination, the King and a trusted counsellor themselves donned workmen's aprons, and in a secret chamber attempted to transmute copper into gold. Their failure was followed, of course, by the exposure of Böttger, who fled into Austria, only to be captured by Saxony soldiery and taken back to prison. That was the end of Böttger's alchemy.

BÖTTGER

He next appears upon the scene as a maker of porcelain. This ware, the making of which had become a lost art in Europe, reached the West only from China, being brought thither by the Portuguese after they had discovered a way to the East by way of the Cape. The ware at its best realised more than its weight in gold. Another alchemist recommended Böttger, as he could not make gold, to make porcelain. Böttger, for all his fraudulent pretences, had a good deal of natural ability, and, investigating the manufacture of the coveted porcelain with great care and zeal, discovered at last a clay which, upon the application of intense heat, became vitrified and retained its shape. The resultant ware was red, and was so hard that it took a high polish, and could be cut by the lapidary. It at once met with a ready sale, and is known as the red porcelain of Böttger. But the real white transparent porcelain was yet to seek. Long Böttger experimented, until one day noting the great weight of his wig, he found that it was powdered with a heavy white earth, which, upon testing, he found to be suitable for his purpose. He at once made ware from this new find; and though the pieces were clumsy and lacked the exquisite delicacy of form and composition of the Eastern original, they were the first genuine European porcelain of modern times.

The Saxon Elector, who had never forgotten the trick played upon him by Böttger, still kept him a close prisoner, and for greater safety built a sort of fortress workshop at Meissen, and there incarcerated Böttger and the workmen engaged to serve him. They were all under military surveillance, and the unhappy Böttger, though the inspirer and genius of the whole establishment, was retained in the position of a mere foreman, with emissaries of the Elector placed in authority over him. Many workmen, unable to tolerate the life of State prisoners, escaped at various times, and carried with them the secret of the manufacture, which in the course of half a century became established at nearly a dozen centres in Europe. To the last, Böttger remained practically a prisoner, and died, on March 13, 1719, in his thirty-eighth year, a heart-broken drunkard. The secret of the factory at Meissen was carefully guarded for a century; and when Napoleon sent an emissary, in 1812, to demand an explanation of the process, the director defied the Emperor until released by the Elector of Saxony from his oath of secrecy.

ZEBULON REED BROCKWAY

An Original Reformer of Criminals

Zebulon Reed Brockway was the man of widest experience in all time in the reformation of men after they had started on a criminal career. He was born at Lyme, in the State of Connecticut, on April 28, 1827. At the age of twenty-one he was a clerk in the Connecticut State prison, and passed from there through a number of official positions in connection with prison and reformatory work that enabled him to gather unique experience.

In 1857 he became deputy superintendent of the Albany Penitentiary. Three years later he was appointed superintendent of the Munroe County Penitentiary, and in 1861 he became the head of the Detroit House of Correction. This experience enabled him to formulate schemes for remedial treatment of men who were beginning a life of crime, so as to bring them back into the body of reputable citizens. In 1876 the State of New York, which had determined to deal in a remedial way with commencing criminals on the lines recommended by Mr. Brockway, appointed him superintendent of its new reformatory at Elmira, and gave him a free hand in the most remarkable manner. For twenty-four years Mr. Brockway held that position, and made the reformatory a model that was copied, more or less, by almost every country. In 1900 Mr. Brockway retired, but in the remaining few years of his life he continued his interest in remedial prison work as a lecturer on penalogy at Cornell University.

The Elmira Reformatory is a material embodiment of the man and his life's work. It brought Brockway's ideas into operation in the very year when Lombroso published his much discussed book "L'Uomo Delinquente," and the criminal became a serious subject of scientific study. Up to that time prison had been a punitive institution, which, incidentally, did harm to everyone who came within its influence. The question Brockway asked himself was whether the prison could not be made to do a man good, and return him to society able to take his place in the ranks of honest industry and keep it with credit. Through a long series of years he proved conclusively that this remedial result can be attained in 80 per cent. of cases if the criminal is taken charge of after his first known serious offence is committed, and is trained carefully for the life after he leaves prison.

The Elmira Reformatory stands in 280 acres of ground, the walled part covering 16 acres. It accommodates 1400 male inmates between the ages of sixteen and thirty, and it cost nearly £400,000. The planning of the prison, the system of treatment, and all the details of management were left wholly in Brockway's hands; and the only criticism of the institution that ever appealed to outside observers was that the liberty of so many men was left under autocratic control. That was a theoretical objection; actually, the facts were wholly favourable.

At the basis of the treatment was the indefinite sentence. No prisoner could tell when he would be discharged—except that he could not be kept beyond the expiry of his sentence. He might be released, however, quite irrespective of the length of time named in the sentence, if he showed rehabilitation of character and a power of earning his living. Life inside the reformatory was regarded not as punitive, but as preparatory to life outside. The usual term was about two years, and in that time it was found possible to train a man for citizenship. Conditional release was granted for six months, and after that period supervision ceased, and the release became absolute, even though the original sentence might be for twenty years.

Reformation by industry was the keynote of the Brockway gospel. That punishment never reformed anybody, but that skilled industry may reform almost anybody, was Brockway's firm belief, and in proving it true he gave a new start to prison administration.

LUTHER BURBANK

The Wizard of Flowers and Plants

Luther Burbank, who is known in his own land as "the wizard of horticulture," was born at Lancaster, Massachusetts, on March 7, 1849. The son of an English father and Scots mother, both of them studious people, Burbank, though in poor worldly circumstances, was happily placed in regard to educative opportunities. There were books for him at home, books to be had of his relatives, books at the local library, and as he grew up he read and pondered everything that came his way bearing upon his favourite hobby—botany. He had no pets or toys, only plants with which to beguile his leisure. School-days ended, he was placed at work in the factory in which his father was already engaged, but preserved his love for gardening. Noticing one day that a certain potato-plant bore a seed-pod, he preserved the seed, and from it raised a potato which proved far superior to others in disease-resisting qualities as well as in fertility. As there was a threat of a potato famine at the time, he was able, without difficulty, to sell his new growth for £30; and it is stated today that that potato, cultivated far and near, has added nearly five millions sterling to the wealth of the agricultural community of America.

Ill-health drove Burbank out of factory life, and with ten of his potatoes and a very slender sum of money he set out for California, the botanist's land of promise. He

experienced great privations, was frequently without means or food, slept in hen-roosts and in damp barns, and was actually at death's door when a charitable woman found him in the place where he had lain down to die, and succoured him with food from her scanty larder. He obtained work at last, and, by frugal living, managed to save sufficient to enable him to rent a small nursery. The clouds of misfortune began to roll away with his first audacious attempt to mould Nature's products to his will.

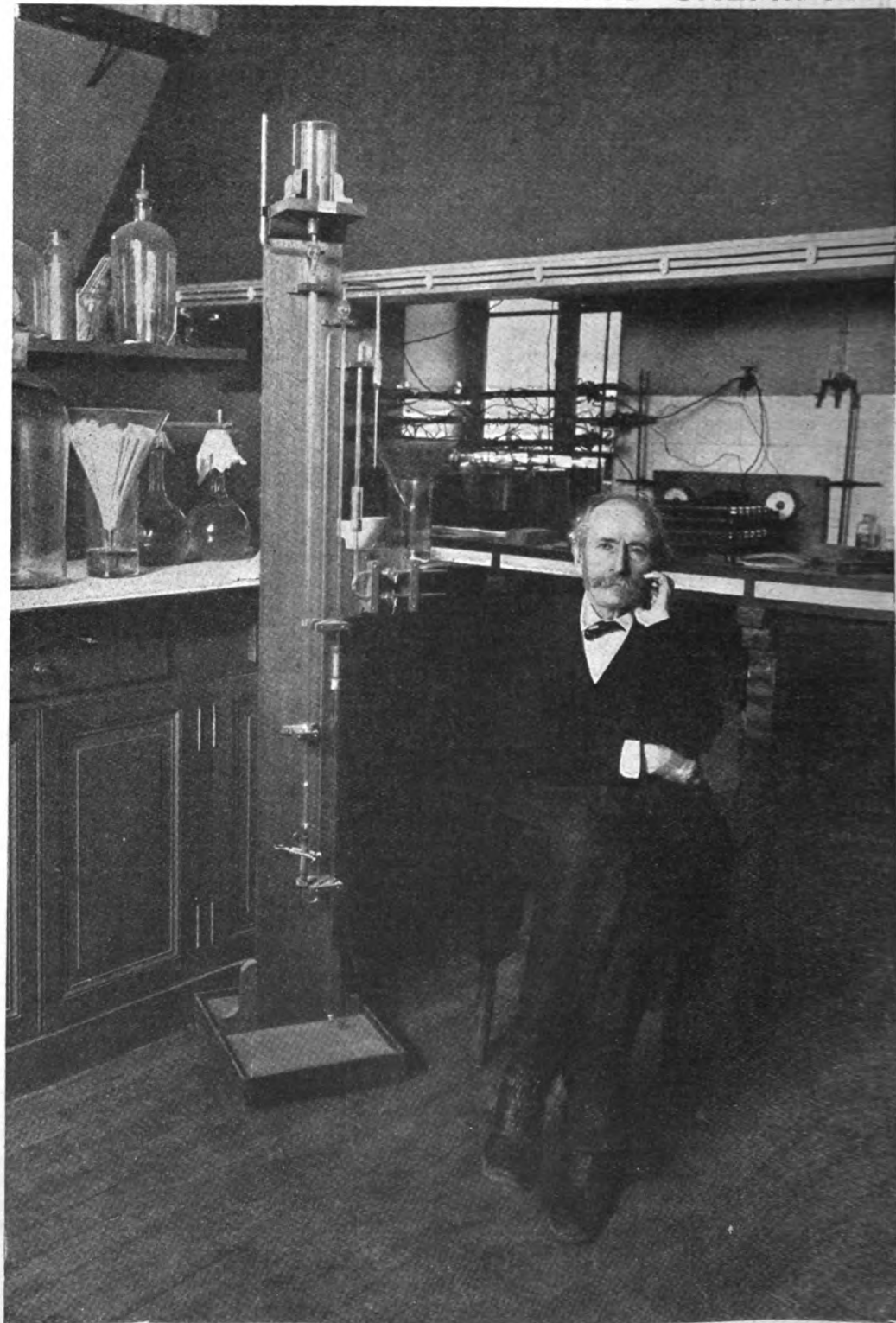
He received an order to supply 20,000 prune-seedlings within nine months. As eighteen months are required to raise a prune-seedling the task seemed impossible. But Burbank had his own ideas upon the subject. He planted 20,000 almond-seeds, which germinated, and at the end of six months had grown so rapidly that he was able to graft prune-buds upon them. He delivered the prune-seedlings within the specified time, and the orchard in which they were planted is now one of the finest in California.

This, his first step in the wonderful progress that he has made in experimental work, shaped his future career. Little by little he withdrew from the ordinary routine of the nursery-garden to develop new varieties of fruits and flowers, by cross-fertilisation, by budding, and by the raising and multiplication of self-fertilised freaks. In these days of fast ships and faster cables a man's fame quickly attracts the attention of distant peoples. Just as Mr. Henry Cannell, a nurseryman of Swanley, Kent, sends large consignments of his produce to South Africa and Australia, so Mr. Burbank, upon a larger scale, was called upon to deliver his goods to European horticulturists. His own friends, particularly those of the ministry, were against him, regarding his work as impious. In the course of a sermon preached in Burbank's presence a minister denounced him for working in direct opposition to the Almighty in thus creating new forms of life which never should have been created, or, if created, only by God Himself.

In 1893 Burbank retired from the nursery business and devoted himself entirely to the task of propagating new growths of flowers, fruits, vegetables, and cereals. He had a long, hard struggle, for fame and capital do not invariably bear one another company. But in 1905 a notable thing happened. The Carnegie Institution, at Washington, decided to grant him an annual £2000 for ten years, to free him from financial care and to enable him peacefully to pursue his investigations, and duly to record results for the benefit of the community.

The results attained are the most surprising in the whole annals of botany. He has produced new and vastly more fertile wheats; he has robbed the edible cactus of its thorns, and made it fit for the food of man and animals, so that in the near future he hopes to see the old and formidable foe of animal life in the desert supplanted by the progeny of the edible cacti of his own nursery. The deserts, he says, will provide in this way a food supply of more than twice the amount required for the whole population of the world. Noting the havoc wrought in California by late frosts, he has evolved trees whose foliage and buds are undamaged by frost, trees which will bloom earlier and fruit later than any others. He has blended the plum and the apricot into a plumcot, a delicious stoneless fruit; has given the world a thornless white blackberry; has multiplied the varieties of apples and pears, so that he has one apple-tree bearing upwards of seventy distinct species, large, small, sweet, tart, red, green, golden. He is constantly making new vegetables, new grasses for paper, string, hats, etc., new nuts, new flowers.

LUTHER BURBANK

All this is the outcome of his own patient investigation, selection, and pollination. His varieties of plums are said to number 300,000; his peaches and nectarines, 60,000; almonds, 5000, and so on. But these are only steps in his ladder of creation. All the 300,000 plums may some day be reduced to half a dozen varieties. His white thornless blackberry was the product of 65,000 separate growths. Without university training, or any of the advantages which the great botanist ordinarily demands, Luther Burbank has revealed more secrets of Nature in regard to the potentialities of her vegetal growths than any complete generation of botanists combined. He obtained his knowledge of general principles from books, but his talent for applying those principles was his own priceless inherent gift.

PIERRE MARCELLIN BERTHELOT, ONE OF THE MASTER SCIENTIFIC MINDS OF MODERN FRANCE

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CHEMISTS & PHYSICISTS

SIR FREDERICK ABEL

The Chemist and the Battlefield

SIR FREDERICK AUGUSTUS ABEL, co-inventor of cordite, the standard explosive in the British Army, was born, the son of a Kennington music-master, at Woolwich, on July 17, 1827. Abel may be said to have been one of the fine products of A. W. Hofmann, under whom, in 1845, the Royal College of Chemistry was founded in London. Liebig's old scientific assistant was not only a great teacher, but enabled his pupils to teach themselves. Sir William Crookes and Sir William Perkin, famous for the discovery of aniline dyes, were of the little company which, with Abel in the class, began its scientific career under Hofmann. Abel soon gained his master's favour, and was made his assistant, a position which he held for the next five years. It says much for both master and pupil that Abel, when only twenty-four years of age, was chosen to take up, in 1851, the post of lecturer on chemistry at the Royal Military Academy, which the immortal Faraday in that year vacated.

Two years later, in conjunction with a scientific friend, he produced a handbook on chemistry which did in its special province for the student what the greater work of Hofmann did for the whole realm of scientific teaching. In the same year he was appointed ordnance chemist, an appointment followed two years afterwards by that of chemist to the War Department. From that time he gradually became the leading authority on explosives, and for nearly half a century was chairman of the committee dealing with the subject. He continued at Woolwich for nearly a generation, during a period when the whole character of military armaments altered.

His investigations and writings covered a very wide field. He was a member of practically all the bodies that had national defence as their object. He abolished the black, smoky powder that was wont to obscure the battlefield or draw the fire of the enemy upon the gunners. He created a new form of explosive by altering the process of manufacturing gun-cotton, so that this might be easily and safely stored, and by his writings furnished the world with exact data on the subject. His most important work in this connection was the creation, in conjunction with Sir James Dewar, of cordite. In spite of all precautions the old-fashioned explosives proved dangerous to handle and to keep. A new form was needed, and these two men, by laborious research and investigation, involving great personal risk, evolved the desired substance. It is composed of gun-cotton, nitro-glycerine, and vaseline ; is named cordite from its string-like, or cord-like, appearance, and is perfectly safe to handle. Indeed, it is said that a recent Minister for War used a quantity of it as a walking-stick. Cordite was adopted for the British Army in 1891, and remains the standard explosive.

Abel's researches extended in many directions, and valuable results attended his investigation of inflammable dusts in coal-mines. He fixed the flash-point for petroleum in this country, was organising secretary of the Imperial Institute, president from time to time of various learned bodies, and an appreciated contributor to the scientific literature of the day. An enthusiast in all that he undertook, he was a strong advocate of a system of tree-felling by explosives, a subject in which Gladstone was naturally interested. As the Premier could not go down to Woolwich to witness a demonstration, Abel went to Downing Street, and there, in the garden of the official residence of the Prime Minister,

showed the efficacy of what he called his explosive necklace.

In order that the trees might be spared, a tall mast was erected for the experiment. The explosive necklace was arranged and fired. There was an explosion that was heard in Hyde Park. All the windows round about were shattered, but the mast had been felled. And, after all, it was to fell trees or masts, not to save windows, that Abel was there. Windows do not, as a rule, occur in forests where the "necklace" was to be employed. Sir Frederick Abel died in London on September 6, 1902.

ANTOINE CÉSAR BECQUEREL
Improver of the Electric Battery

Antoine César Becquerel, an illustrious father of an illustrious family, was born, March 8, 1788, at Châtillon-sur-Loing, in the department of Loiret, in the heart of France. He is one of the most famous of French students of chemistry and electricity; and his sons and grandsons and great-grandsons have nobly continued his work, and made the name of Becquerel a mark of intellectual aristocracy. Even the English family of Darwins can scarcely show so continual and magnificent an output of scientific achievement. It was an accident that turned the mind of the older Becquerel to the pursuit of knowledge. Brought up amid revolutions, invasions, and raids that carried the French flag in victory from end to end of Europe, the boy was dazzled by the glory of a military career under Napoleon. In 1806 he entered the Polytechnic School at Paris, and so distinguished himself that at the end of two years various careers were open to him. He chose the army, and went as sub-lieutenant to Metz to complete his engineering knowledge. The following year he started out for Spain as an engineer officer in the army of General Suchet.

From 1810 to 1812 he worked with skill and energy at six great and terrible sieges. He was mentioned several times in the order of the day for his brilliant actions. At Tarragona he built and defended a redoubt in the face of an overwhelming number of enemies; and for this he was given the command of one of the three assaulting columns that captured the town. He was one of those men whose mind is a sword that quickly wears out its bodily scabbard. He was never strong, and only by sheer strength of will did he manage to keep on his feet.

The rigours of the campaign undermined his delicate constitution, and at the age of twenty-four, when he was made Knight of the Legion of Honour, he was compelled to retire. The position of under-inspector of studies was especially created for him at the Polytechnic School, and on entering on his duties in 1813 he married. When France was invaded by the allies, he again went out into the firing line, but again, at the age of twenty-seven, his health entirely gave way, and he had to leave the army. For some time he hesitated in the choice of a new career. He was so versatile that there were many openings before him. He chose at first the study of minerals, but, finding that they had electrical properties, he took up electricity.

He had now found his proper field of work; and the five hundred works which he wrote during his long life were almost exclusively devoted to discoveries made by him in the new and obscure branch of physics. There is not a chapter in the history of electricity to which he has not contributed something of importance. To him we owe the theory of the electric battery. Volta discovered that when a positive and a negative metal, such as copper and zinc, are brought into contact, an electric current is produced. Becquerel showed that the production of electricity is not caused by the contact of the two metals, but by the chemical action between them. Broadening out this idea, he proved that the molecules of a metal work by friction, heat, chemical action, or pressure in the development of electricity.

He greatly improved the electric battery, and enabled a constant current to be obtained from it. He showed how elements of various kinds could be obtained by means of an electric current, and he invented instruments of great precision for measuring electro-magnetic forces. Our Royal Society bestowed on him their highest honour. Becquerel loved his country, his family, and science. He was an accomplished soldier, an illustrious discoverer, and the best and wisest of fathers. On the education of his two sons he spent the most loving care, and established the great Becquerel tradition, which is as strong at the present day as it was when his son, Alexandre Edmond Becquerel, succeeded him, on his death on January 18, 1878, as Professor at the Musée d'Histoire Naturelle.

ANTOINE HENRI BECQUEREL
Father of the New Alchemy

Antoine Henri Becquerel, the son of A. E. Becquerel, and grandson of Becquerel the first, was born in Paris on December 15, 1852. He held the family professorships, winning them, of course, entirely by personal genius, and he completely

revolutionised the foundations of modern science. To him is directly due the discovery of radium and the radio-activity of matter. So, indirectly, he is the father of the new alchemy, whereby elements that were thought to be unchangeable are split up and transformed into different elements. His father, A. E. Becquerel, had spent his life in important researches on light and electricity. Antoine Henri developed these researches, and discovered that certain forms of matter emitted a mysterious radiance. It was Röntgen's discovery of the wonderful X-ray that excited Becquerel. He returned to his grandfather's early study of minerals; and after some experiments on uranium he found that this element at ordinary temperature gave forth an invisible ray that passed through thin plates of metal, and affected a photographic plate.

For his work on the problems of radio-activity he was, in 1903, awarded a Nobel prize jointly with Curie, whom he had put on the track of radium. Like his father and grandfather he did important work on magnetism and polarised light and phosphorescence. He was, besides, a great engineer, and directed the bridge-building of France; he also taught in the Polytechnic School of Paris, in which he and his father and grandfather had studied as boys. His activities were so diversed and so great that he wore himself out in middle age, and died at a holiday resort in Brittany on August 25, 1908. But a fourth generation of the Becquerel family is continuing the scientific work in which their ancestors had laboured for a hundred years, and reports of their discoveries are continually published.

PIERRE EUGÈNE MARCELLIN BERTHELOT
Founder of Synthetic Chemistry

Pierre Eugène Marcellin Berthelot, one of the master-minds of France, was born at Paris on October 29, 1827. The son of a doctor, he distinguished himself as a boy by the variety of his studies, and at the age of nineteen he won in open competition the prize of honour in philosophy. But by this time he was convinced that thinking about things led nowhere, and he threw himself into the pursuit of experimental science, and, without passing through any school, he won, in 1854, his degree of doctor of science. Appointed to the humble position of manual assistant to a professor of chemistry at the College of France, he served him quietly for nine years, but spent his leisure time in carrying out a series of remarkable experiments which enabled him to construct a new system of chemistry. No one at that time thought that man would ever be able to make in laboratories and factories the substances produced by living bodies. It was held that a mysterious vital force working in plants and animals could alone create out of non-living matter the compounds manufactured in living cells.

So when Berthelot published, in 1860, his great work on "Organic Chemistry Founded on Synthesis," the effect he made on the general mind was similar to that made by Darwin's "Origin of Species." But there was no disputing the conclusions of the French chemist. His experiments in building up the products of living things could be repeated and verified by any man who followed his methods. So the success of his system and his ideas was instantaneous. The professors of the College of France and the chemists of the Academy of Sciences demanded from the Government the creation of a special Chair of Organic Chemistry for Berthelot. This was done at last, in 1865, and for forty-two years Berthelot worked without interruption in a position of high authority.

In person he was a small, quiet man with a remarkably large head. Having, as he proudly announced, shown there was no mystery remaining in the universe, and reduced the processes of life to a matter of chemical laws, he was at heart one of the most melancholy of men. He could not understand the gaiety of mind of Renan, his life-long friend, whom he met when they were both poor and struggling lads in Paris. There is much in Renan's work which is derived from conversations with Berthelot, who was a brilliant thinker of wide range, as well as a specialist in the most important branch of chemistry. Intensely patriotic, Berthelot took an active part at the Siege of Paris. He directed the making of cannon and the manufacture of gunpowder and dynamite, and planned the researches of one of his pupils that led to the invention of modern smokeless powders of high energy.

Out of this practical work Berthelot developed another branch of science in which he again did some masterly pioneering labours. Taking up the chemistry of heat, he undertook a series of dangerous and delicate experiments with the most powerful explosives. He showed that an explosive energy proceeded in waves, and he measured the length of these undulations of terrific force. Out of the science of explosions that he constructed comes much of the practical applications of the highest energies to industrial purposes.

Berthelot would have been a very rich man if he had patented his discoveries. But he refused to make money out of his ideas, holding to the noble conception that a true man of science should work freely with the sole aim of increasing the knowledge, power, and welfare of the human race.

To escape from the melancholy of his soul—a melancholy caused, perhaps, by the fact that he was a man of a soaring spirit imprisoned in a blind, dead, mechanical universe that he himself constructed—he tried to drug himself with work. He was indeed the most hard-working man of his age, and as he grew older his passion for work increased. Not content with his constant labours in three departments of chemistry, he took up the study of electricity, and was the first to attempt to electrify growing crops. His lectures on science at the College of France went on for forty years and more, and all this time he directed and helped in the researches of his pupils.

COUNT BERTHOLLET VISITING LAVOISIER

Having always been a Republican of an impassioned kind, he took no part in political life under the Second Empire. But he was one of the forces behind the Third Republic, and he shed lustre on the Government of his choice, by acting first as Minister of Education, in 1886 and 1887, and taking over the conduct of Foreign Affairs in 1895. When his scientific jubilee was celebrated in 1901 by a great State function, all the world attended to honour him. He died March 18, 1907.

CLAUDE LOUIS BERTHOLLET

The Tragedy of a Great Man

Count Claude Louis Berthollet, one of the most famous French chemists, was born at Talloire, in Savoy, December 9, 1748. Belonging to a family remarkable for its ingenuity and its poverty, he took up the study of medicine as a means of livelihood, and received the degree of doctor from the University of Turin at the age of nineteen. For four years he stayed at Piedmont, and then went to Paris in search of knowledge and food. Being a young man of great charm of manner and brilliant conversation, he approached the most famous physician of the age, Tronchin, who had great influence at the French Court. Tronchin was struck with the talents of the starving young doctor, and obtained for him some noble patients, together with the freedom of the chemical laboratories in the Palais Royal.

Medicine was merely regarded by Berthollet as a means of existence. His real passion was for chemical study, and in 1784 he won an apparently humble position of director of the royal dye-works. But he was one of those men of commanding genius who do not wait for favourable opportunities, but create them. Introducing chemical science into an industry that dates back before human memory, he astonished the world by making the first striking application of scientific ideas and methods to a traditional branch of work. At that time the bleaching of fabrics preparatory to dyeing them was a long and defective process. The cloth was washed many times, and after each operation it was spread on a field so that the air and light and dew would slowly take the colour out of it. Berthollet, in 1785, worked out the modern method of rapidly and completely bleaching fabrics by means of a preparation of chlorine, thereby revolutionising the dyeing industry and bringing home to everybody

the high practical value of the new science of chemistry. He gave also an admirable example of the disinterestedness of men of science by throwing his invention open to the world and doing all he could to get men to use it freely. No personal profit was derived by him from his researches.

His chemical work, however, made him popular as well as famous ; and at the height of the French Revolution he was regarded by all parties in France as one of the sources of wealth and strength of the country. Continuing his researches on chlorine compounds, he came upon the highly explosive potash combinations. As these were much stronger than gunpowder, he attempted to experiment with them as a propellent for firearms. The essay was made in the presence of the director of gunpowder manufacture and four other persons. But the explosion destroyed the building and buried the spectators beneath the ruins. The disaster led Berthollet to reject the use of his new explosive, which went off with murderous facility. But as the French Republic was in great danger from its enemies, he continued to risk his life in the search for new explosives, and, at terrible peril, discovered fulminating silver, and then helped the French Government as a chemical handy-man.

He looked to the qualities of the soldiers' ammunition, sought for fertilising chemicals to improve the crops of the country, and went to Italy to collect for the Government the masterpieces of the great Italian painters, and discover more scientific methods of cleaning the canvases. In Italy he met the young General Buonaparte, who became greatly attached to him. His practical achievements so convinced Napoleon of the value of science that he became a pupil of the chemist, and attended his lectures on returning to Paris.

It was to Berthollet that Napoleon confided his secret plans for an expedition to Egypt, and asked him to collect a band of men of science to accompany the army. Bread-making, beer-making, gunpowder manufacture, iron smelting and steel tempering, the erection of hospitals, and the establishment of a botanical garden were a few of the tasks that the brilliant young chemist helped to direct while following Napoleon in the Egyptian campaign.

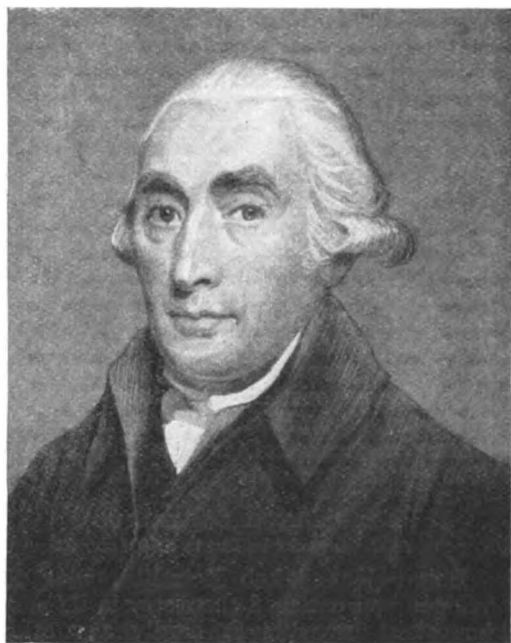
In 1804 Napoleon made Berthollet a Count of the Empire and Administrator of the Mint. By this time the chemist was a rich man, but, remembering his own early struggle, he spent most of his money in helping younger men of science who were in difficulties. Most of his savings he gave to his son, but the young man set up as a manufacturer, and failed. And so ashamed was he of going bankrupt that, finding his father had no more money, he committed suicide.

Berthollet was heart-broken and prostrate at being unable to save his boy. This happened in 1811, and Napoleon, on hearing of his poverty and sorrow, at once sent him one hundred thousand crowns, and said he was hurt that his old friend and master had not come to him for help. Berthollet never recovered from the shock of his son's death ; the money he needed came too late.

The rest of his life was one of outward splendour. He was made a peer of France on the restoration of the Bourbon kings, and his fame in science was continually increased by the chemical discoveries he made. He loved to surround himself with younger men engaged in scientific study, and impart to them his remarkable store of knowledge. He aimed at reducing the phenomena of chemistry to physical laws, and he was most successful in dealing with the decomposition of salts by acids. He was a follower of the great French chemist Lavoisier, and with him reformed the terminology of the science. Most of his writings are remarkable for the clearness with which they are written, for their scientific importance, and for their usefulness in arts and industries. He died of a fever on November 6, 1822, at the age of seventy-four.

JÖNS JAKOB BERZELIUS
A Discoverer of Facts and Laws

Baron Jöns Jakob Berzelius, who developed and enriched chemistry in its most important branches as hardly any other man has done, was the son of a schoolmaster of East Gothland, Sweden. Born on August 29, 1779, in a farm at the village of Väfversunda, he was left an orphan at the age of nine, and in his youth had to endure many cares and privations. While still a boy he acquired a love of chemical research, and, after many difficulties and disappointments, was able to complete his education at Upsala University. Unfortunately, the teaching he received in chemistry was dull and uninspiring. So he turned to the study of medicine, and graduated as a doctor in 1802. In the meantime, however, he kept up as a hobby the study of chemistry, and by his own unaided efforts obtained a practical and experimental knowledge of the young science.

An early work on the action of an electric current on salts made him famous at the age of twenty-two, and in 1802 he was appointed assistant professor in medicine, botany, and the study of drugs at Stockholm. His salary was very small, but he added a little to his income by medical practice. During a visit to London, in 1812, he attended the lectures at Guy's Hospital, and he was there inspired, by the experiments that the lecturer, Dr. Marcet, introduced as illustrations, to adopt the same method on his return to Sweden. In 1815 a Chair for chemistry was found for him at Stockholm, and he broke away from the Continental tradition of giving lectures on pure theory, and attracted

JOSEPH BLACK

students, in the English fashion, by his illustrative experiments. In his modest home he used a small scullery as a laboratory, and in this humble chamber laid the basis of a large part of modern chemistry.

In 1823 the famous German man of science, Wöhler, journeyed to Stockholm with a view to spending a winter in Berzelius's laboratory. Naturally he expected to find a well-appointed room, fitted with all manner of ingenious instruments. He knocked at the door of the house, and it was opened by a tall man with a florid complexion. It was Berzelius, the most famous of European chemists. Asking to see the laboratory where so many mighty discoveries had been made, the astonished German was conducted to a little place off the kitchen, where there were a couple of plain tables, a blowpipe, a shelf or two of bottles, and a barrelful of water for washing the laboratory dishes. In the kitchen, in which the cook was working, were a small furnace and a sand-bath, and this completed the outfit of the man who had revolutionised a whole science.

Here the atomic weights of the greater number of the elements had been determined accurately. New elements had been discovered, and the properties of uranium and platinum and the rare earths now used in incandescent mantles had been examined. No chemist has added to the science so many carefully determined facts as Berzelius. He was always at work in his kitchen or scullery, and, in spite of his primitive appliances, he worked with the most exquisite skill. He was one of those workmen of genius who can make up in inventive power for the lack of tools and the money to buy tools. Berzelius indeed made, just for this reason, most ingenious advances in the technique of the chemical laboratory.

Great as he was as a discoverer of facts, he was still greater as a discoverer of the laws that connect facts together, and point the way to larger fields of knowledge. His inventive output was not, perhaps, so great as that of his English contemporary, Davy, for he lacked appliances. But by strict methods of procedure and incessant study and observation he built up a famous theory of chemical proportions, which formed the foundation for the work of other men.

The fine qualities of the man were shown in his relation to the large and brilliant band of young men of science who gathered about him from all parts of the world. His kitchen was at their disposal, and so was his genius. Unlike some modern men of science, he did not claim the honour of discoveries made by the younger men whom he directed and helped in their researches. He was too rich in achievements to keep his assistants subordinate to his fame. Just and unselfish, he was ready to give his pupils more than their full credit for discoveries of which he was the real begetter, in order to bind them in youth to a life of original research. This is one of the reasons why his teaching was as productive of large results as his experiments and theories were. He was one of those rare men with a gift of creating genius in others. He was made a baron in 1835, and his life of incessant discovery ended on August 7, 1848.

JOSEPH BLACK

Founder of the Real Science of Chemistry

Joseph Black, one of the founders of scientific chemistry, was the son of a Belfast wine-merchant. He was born near Bordeaux, in 1728, and his childhood was passed in France, but at the age of twelve he was sent home to a school at Belfast. A quiet, pleasant boy, of a rather frail constitution, he was devoted to study, and his father, a man of unusual knowledge and liberal sentiments, sent him in 1746 to the University of Glasgow. While at Glasgow, Black resolved to follow a medical career, and at the same time he began to take an interest in chemistry. But it was at Edinburgh University, where he went to complete his medical studies, that the young man from Belfast revealed his genius and founded the real science of chemistry.

At the time many medical men were using quicklime and potash, in the form of caustic potash, to counteract stone in the bladder. It was thought that when limestone was treated with fire the quicklime so made derived from the fire a " fiery power." This fiery power the quicklime handed on to the potash, and that was how the caustic potash acquired its power of corroding animal matter! Black resolved, in the ardour of youth, to go in pursuit of this " fiery power," and lay hold of it. For three years he delayed taking the degree of Doctor of Medicine, in order to make sure that his experiments were complete and his conclusions well founded. Then, in his famous thesis for the M.D. degree, he dismissed the fiery power into the limbo of mad fancies, and showed that the causticity of lime and alkali is due to the absence of the carbonic acid which was present in the limestone and certain forms of alkali.

The work that Black completed when he was twenty-six years of age is the first accurately quantitative examination of a chemical action which we possess. By it he began the high task of transforming chemistry from a fanciful, weak, and obscure art into a methodical science of universal range and tremendous power over the lives of men. Happily, his worth was at once recognised, and in 1756 he was appointed Professor of Anatomy and Lecturer on Chemistry in Glasgow University. This enabled him to form and train a school of young, scientific chemists; and among his pupils was James Watt, who remained his friend for life. Adam Smith, the famous political economist; David Hume, the no less celebrated thinker, and Dr. Hutton, one of the earliest workers in geology, also became his intimate friends.

In the ordinary way, however, Black preferred the society of cultivated men and women to that of men of science. When his work in the laboratory and lecture-room was over, he liked to go out in the world and recover the sense of life.

At Glasgow, and later in Edinburgh, he was more concerned with the methods and principles of chemical science than with the discovery of new facts. He wanted to forge the instruments of research, and train the men of the younger generation in the use of them. Unlike many highly original minds, he had a gift for teaching; and he delighted in exercising it. In his lectures he threw new light on the whole range of chemical science. From him men like Watt caught the fire and the knowledge that led to great achievements.

His own finest piece of experimental research was that on latent heat. This occupied him from 1756 to 1761. He melted a piece of ice to water, and then turned the water to steam. He measured the amounts of heat required in these two operations. He showed that the heat was absorbed by the ice and the water, and that it was restored to surrounding substances when the steam again became water and the water congealed to ice. This kind of heat he called latent heat, because its presence was not revealed by the thermometer. James Watt assisted him in his final experiments with steam.

In 1766, Black was appointed Professor of Chemistry at Edinburgh, and in this position he remained till his death, on December 6, 1799. Being at table with his usual fare—some bread, a few prunes, and a cup of milk-and-water—he took the cup in his hand, and died with a smile, holding the cup, and even in death not spilling the milk. He was always a careful man, was Joseph Black!

WILLIAM ARTHUR BONE

Inventor of Heat without Flame

William Arthur Bone, the author of the greatest revolution in industrial science of our time, comes from Stockton-on-Tees. There he was born on March 19, 1871. He first attended the Friends' School at Ackworth, and afterwards went to the Grammar School at Stockton and the Leys School at Cambridge. Taking up the study of chemistry in boyhood, he graduated at the age of twenty in the Honour School of Chemistry at the Victoria University of

Manchester. The science of metals was at this time his especial study, and it was in search of an easy way of obtaining the intense heat necessary in dealing with some refractory materials that he made his great discovery. He won a scholarship, and was elected Fellow of Victoria University at the age of twenty-one. But in order to broaden his knowledge of the chemistry of products of living bodies he went to Heidelberg in order to study under Victor Meyer, one of the finest of organic chemists of the latter part of the nineteenth century. His own work, however, has mainly lain in an entirely different direction from Meyer's researches. On returning to England, Professor Bone

ROBERT BOYLE

was appointed, in 1896, head of the chemical department at the Battersea Polytechnic in London; two years afterwards he was made Lecturer in Chemistry and Metallurgy at Owens College, Manchester. His brilliant success as a teacher, however, was now only of secondary importance in his career. He was already engaged upon the long and difficult researches on combustion which have had so extraordinary a result. From 1905 to 1912 he worked at Leeds University as Professor of Applied Chemistry; and here he took Mr. C. D. McCourt as a fellow-worker in his special invention of flameless heat.

He had discovered that, by mixing coal-gas and air, and sending it in a jet on a screen of porous material, an amazing amount of heat could be produced. All the energy usually wasted in the flames of a fire were transformed into a flameless heat. So high were the temperatures thus obtained that the chief difficulty was to find a material that would resist the heat. This was at last done by means of a special fire-clay, and on March 30, 1911, Professor Bone was able to announce the invention of the Bonecourt system of flameless combustion. By this system it is easy to obtain a degree of heat twenty times more powerful than the fire required to boil water, and in many cases the cost of fuel is practically halved.

Almost every industry in which work is done by heat is affected by the new discovery. The smelting of metals and the annealing of iron and steel, the making of glass and cement, the riveting of ships and bridges, and the steel-work of large buildings, the distillation of water, oil, tar, and zinc, the production of steam power, and the calcination of minerals are merely a few of the industries revolutionised by Professor Bone. His system is applicable to domestic purposes and to chemical work.

The economy of the new flameless heat is well displayed in the new steam-engine recently exhibited in London. In it ninety-five out of every hundred parts of the heat-energy of fuel are converted into steam power. So important are the results of Professor Bone's years of research that in 1912 a special position was created for him at the Imperial College of Science, London, by means of a Professorship of Fuel and Refractory Materials.

ROBERT BOYLE
Hero, Thinker, and Inventor

Robert Boyle, the father of chemistry, was the fourteenth child of the Earl of Cork. He was born at Lismore, on January 25, 1627. His father came to Dublin at the age of twenty-two, with a handsome suit of clothes on his body, and twenty-seven pounds three shillings in ready money. As his son relates with pride, he built out of this small beginning so eminent a fortune that he was the wonder of his age. Boyle himself was a studious, sickly boy, with uncouth manners, stuttering speech, and roving ways, but that brilliant man of the world, Sir Henry Wotton, took him in hand, when he was sent to Eton at the age of eight, and turned him into a courtly gentleman with an inquiring mind. In boyhood Boyle nearly lost his life through the mistake of a careless apothecary. This

accident made him for the rest of his life fear doctors more than disease; and, what is of more importance, it also made him apply himself to the study of physic, so that he might not need help from physicians.

From the study of drugs he acquired an interest in the chemical art of preparing them; and if he did not completely turn this art into a science, he at least laid the foundation for its scientific development. During the troubles of the Civil War, he joined the Invisible College. This sounds like a secret political society, but it was really composed of a few gentlemen who were interested in the new school of experimental science, of which Bacon was indirectly the author. The little band of inquiring minds used to meet weekly at each other's lodgings in London or at Gresham College, Boyle's house being from 1654 the usual meeting-place. Out of the Invisible College grew the Royal Society of London for Improving Natural Knowledge, which was incorporated by Charles II. in 1662, with Boyle among the members.

Then the cry went up that religion was being undermined and civil law destroyed, and the empire of reason and true learning overthrown. Pious bishops and atheists like Hobbes attacked the society, and satirists like Samuel Butler, the author of "Hudibras," lampooned it. Boyle was entreated, for the sake of religion and the good of his country, to abandon his scientific companions. But the Great Plague and the Great Fire gave the society its opportunity, and much of what was good in the arrangement of the new city was the result of their discussions and councils. They made science fashionable, and even the good-for-nothing King set up a laboratory and amused himself by making weather observations.

Boyle began his chief experiments in 1659, with the construction of his famous "pneumatical engine." This was an apparatus for creating a vacuum, and studying the properties of the air. He was very cautious in drawing conclusions from his experiments, as befitted a man who printed in 1661 a work entitled "The Sceptical Chymist." But through his caution and his thoroughness of investigation he was able to formulate the law of gases known by his name, which is of supreme practical importance in the design and working of steam-engines. His "Sceptical Chymist" contains a greater number of well-authenticated facts than is to be found in any other treatise of its day. Boyle made alcohol from wood, and acetone from lead and lime.

Born in the year after Bacon's death, he is the first true exponent of the Baconian method. His fame and his social position made his personal influence very considerable, and the work that he did to advance scientific knowledge was of high importance. His house was constantly crowded by patentees and inventors, and he spent a good deal of his income in helping poorer men of science. He was the inventor of the term "chemical analysis"; and by his discoveries of many means of discerning the presence of known chemicals in unknown compound substances he did much to forward that branch of the new science of which he was godfather.

SIR DAVID BREWSTER

Yet the remarkable labours of his life were carried out in suffering, for he was the victim of grievous ill-health. Somewhat of the superstitions of the mediæval alchemists clung to his mind, for, like Bacon, he was inclined to believe in the transmutation of gold. But perhaps, now that we have arrived at the new age of alchemy, these strange notions of the most cautious and doubtful man of the modern school may be regarded as premonitions of the great discovery of the age of radium. Boyle was only sceptical in matters of scientific theory; in matters of religion he was a profound and impassioned believer. A feeling of awe excited in him in boyhood during a thunderstorm remained the main-

spring of his life and he established the "Boyle Lectures" in defence of Christianity. He died on December 30, 1691, and was buried at St. Martin's-in-the-Fields.

SIR DAVID BREWSTER
Inventor of the Kaleidoscope

Sir David Brewster was born at Jedburgh, on December 11, 1781, the son of the rector of the local grammar school. Although from his earliest years he showed decided inventive talents, and made a telescope when he was but ten, he was destined by his father for the Scottish Church, and at twenty-three preached his first sermon. He showed considerable talent as a preacher, but the strain was too great for his nervous system, and reluctantly he abandoned the pulpit for the editorial chair and the post of tutor. He was early brought in contact with the foremost Scotsmen of his day, and throughout his long life had a host of friends on the Continent as well as in his own land. He failed to secure election as professor of mathematics at either Edinburgh or St. Andrews, but was made LL.D. of St. Andrews, and M.A. of Cambridge.

Before he was thirty, he had begun that long series of investigations of the properties of light and of optics which brought him fame. He improved the stereoscope of Wheatsone by introducing refracting lenses and inventing the kaleidoscope, which for nearly a century has been sold in vast numbers as a charming toy, but also as an instrument of utility. Some of the most beautiful designs for lace curtains and other fabrics have been made from patterns supplied by its endless variety of figures. The pity is that, owing to an error in the patent specification, the inventor never derived a farthing from it.

His daughter has described the enthusiasm which the toy caused in England and America, and how, on the luckless inventor's visit to London to seek protection for his invention, he found kaleidoscopes to right and left, all pirated copies. One manufacturer undertook to make kaleidoscopes for Brewster, provided that he got the permission of the gentleman for whom he was already manufacturing them. Another example, he was told, was the patent of a London doctor, in so far as the interior was concerned, but that the tinman who made the toy had patented the tin covering, and the two were at loggerheads as to the whole. However, honour proceeded indirectly from it, for the kaleidoscope resulted from Brewster's experiments on the polarisation of light by successive reflections between plates of glass, and these experiments brought him the Copley medal.

A prodigious worker, Brewster edited various educational works, contributed an enormous number of articles on scientific subjects to the reviews and encyclopædias of the day, wrote admirable biographies of scientists, introduced important improvements into the lanterns of lighthouses, examined and explained the nature and cause of colour-blindness, from personal observation of his friend John Dalton, in whom the infirmity was first discovered, and helped to found the British Association, of which he was one of the first and most honoured members.

He marched out with the 474 protesting ministers who quitted the Church of Scotland, and in doing so nearly lost the principalship of the college of St. Salvator and St. Leonard in the University of St. Andrews. The whole life of this indefatigable man was given to science and literature, and his work and worth were recognised by the bestowal of many titular honours, as well as by a pension from the Government.

He was greatly beloved in private life, and, for all his exhausting researches, could enjoy a joke as well as his gayest friends. A typical jest in which he shared was that practised at the house of the Duchess of Bedford. Brougham, Lord Chancellor at the time, was among the guests, and after his withdrawal to bed it was decided to see whether he really did, as tradition alleged, sleep upon the Great Seal of State. A soft cake of dough was made, and a procession of nobles and others, headed by Brewster carrying two enormous silver candlesticks, and the Duchess with the dough upon a silver salver, marched up to the bedroom, where Brewster peremptorily demanded that the Great Seal be brought into use. Brougham ruefully whispered to his friend that he could not get up, but he gravely stamped the dough with the Great Seal, the procession retired satisfied, and the Chancellor returned to his pillow. Brewster died at Allerly, Melrose, on February 10, 1868.

ROBERT WILHELM VON BUNSEN
A Great Developer of Chemistry

Robert Wilhelm von Bunsen, to whom chemistry is indebted for a great number of important researches in every part of the science, was born at Göttingen on March 31, 1811. Among his inventions of a more general kind are the Bunsen burner, the

magnesium light, and the Bunsen cell. He also took a chief part in founding the science of spectrum analysis, by means of which the flame from a chemical retort or the light from a distant star can be made to tell of what burning elements it is composed. He was educated in his native town and in Paris, and after holding a series of professorships in different parts of Germany he was called, in 1852, to Heidelberg. For many years he remained the master-mind of this university, which he made one of the great scientific centres of Europe.

At the age of twenty-six he began his first important research, and for six years he studied a certain compound of arsenic. He made his name over it, but came out rather damaged, having lost the sight of one eye through an explosion, and being nearly killed by arsenical poisoning. His experiences somewhat diminished his interest in this branch of work, and he let his English pupil, Sir Edward Frankland, go on with it alone, and win high fame by a series of brilliant successes. Bunsen also took up, at the beginning of his career, the study of the gases given off by blast furnaces. This branch of his work was of great and immediate practical importance. He was able to show that in German furnaces almost half the heat yielded by the fuel was allowed to escape with the waste gases. Coming over to England to investigate our furnaces, he revolutionised the methods of our manufacture of iron, by proving that 80 out of every 100 heat-units went up the chimney with the waste fumes. This striking application of the principles of chemical research to an important industrial problem served to awaken our ironmasters to the high practical value of modern science, though many years passed before we learnt to convert the waste gases from blast furnaces into a source of power.

Bunsen was a man with a remarkable range of mind, and in 1841 he adventured into the borderland between chemistry and electricity, and invented the carbon-zinc electric battery, now generally known as the Bunsen battery. By using it to produce an electric arc, he obtained out of a pound of zinc a light equal to nearly 1200 candles. Each pound of zinc used in the batteries lasted an hour. Then, in order to measure exactly the amount of light that he so obtained, the famous chemist invented another instrument, the grease-spot photometer, which remains in general use. It consists merely of a sheet of white paper, in the centre of which is a grease-spot. The sheet is placed on a slide in the middle of a table, and a standard candle is placed at one end of the table, and the light to be measured at the other end. The paper is slidden up or down until the grease-spot becomes invisible, owing to the lights on both sides of it being of equal power. The scale on which the paper has been slidden then shows the value of the tested light.

In 1852 Bunsen began to use his battery in another ingenious way. He sent the current through various solutions, and separated the substances therein. By this means he obtained magnesium in its metallic state, and turned his discovery into a matter of importance to photographers by studying the brilliance and properties of the magnesium flashlight, and proving how quickly it acted on a photographic plate.

The famous Bunsen burner was invented by him as an aid to chemical research. In 1855 a new laboratory was built at Heidelberg, and Bunsen was asked to look at the various devices proposed for supplying heat for use in chemical operations. A blowpipe was generally employed for the purpose, but Bunsen wanted something more convenient to handle. Finding nothing to suit him, he quickly devised a simple means of burning ordinary coal-gas in such a way as to produce a hot smokeless flame. His burner was so excellent and easy a means of obtaining an intense heat that it has come into general use.

Huxley used to say that Herbert Spencer's idea of a tragedy was that of a theory killed by a fact. Bunsen was remarkable for his dislike of theories; he never troubled about them, even when the chemists of Europe were divided into two warring camps, each with a separate theory. He kept to facts, and especially to the discovery of new facts, and new methods for arriving at facts. The result is that the only book he published, which was on gas analysis, is as sound today as when it was written; it is not only a storehouse of information, but it practically still covers the whole field.

Bunsen was so continually successful a man of science that we cannot attempt to enumerate his discoveries. There is, however, one achievement of his so tremendously important that it dwarfs all others. Following a strange discovery made by a fellow-worker in 1860, he took a main part in the work of finding out the significance of the thousands of faint

dark lines seen on the band of colours formed by passing sunlight through a three-sided piece of glass. By developing his methods we are now able to get photographs of iron-storms and other whirling masses of flaming elements on the sun. We are able to go upon mining expeditions among the stars. Bunsen died at Heidelberg on August 16, 1899.

NICOLAS LÉONARD CARNOT

A Founder of Modern Physics

Nicolas Léonard Sadi Carnot, the founder of the science of thermo-dynamics, a son of the organiser of victory under the First French Republic, and the uncle of President Carnot, of the Third Republic, was born on June 1, 1796, in the Luxembourg Palace, Paris, where his father was still engaged in organising the fourteen armies of the Revolution. The next year the elder Carnot had to flee to Germany. He returned to help Napoleon, but threw up his work when he discerned the tyrannical ambitions of the young general. In 1812 he sent his son Sadi to the Polytechnic School at Paris; and when the allied armies invaded France in 1814, young Sadi took part in the defence of the capital, while the father heroically defended Antwerp.

The restoration of the Bourbons was a heavy blow to this Republican family, who would not take even Napoleon for a master. The older man left France, and died in exile. But Sadi wanted to show he inherited his father's genius. He entered the French Army, and quickly won a lieutenancy, but was forced to send in his resignation in 1828, through the fierce ill-will of his superior officers. The Royalists wanted no Carnot in command of the men But this was really a happy event in the history of our industrial civilisation. For Sadi Carnot was a young man of the highest genius, and to keep his mind bright he attacked the most obscure problem in science, and obtained a solution of the greatest practical value. The founder of the science of thermo-dynamics, he studied especially the laws of heat, and their applications to the development of the steam-engine, and all prime movers in which heat is used.

His celebrated treatise, "Reflexions on the Motive Force of Fire, and on the Machines Proper to Develop this Force," was published in Paris in 1824. No one in France paid any attention to it, but in England it created a revolution in mechanics, which is still far from having lost its force. Long after Carnot's death his fame spread to his native land. One of the results was that France then began to lead the way in the invention of the next new prime mover—the gas-engine. Later on, a young Austrian man of science went back to Carnot, and astonished the world with the invention of the Diesel oil-engine.

Carnot was struck by the fact that only luck and practice seemed to direct the gradual improvements of the design and construction of steam-engines. He resolved to raise this branch of engineering to the rank of a science. He began by stating in a methodical and general manner the problem of the relations between heat and work. He remarked that in all heat-machines there is a fall of temperature, such as takes place between the boiler and condenser of a steam-engine; and he showed there was no transformation of heat into work without this fall. He then formed his famous idea of a perfect engine that would change heat so completely into work that the work could be changed back into the amount of heat that produced it. He established the limits of power of all heat-engines—steam, gas, oil, alcohol motors—and then he went on to mark out the lines on which all prime movers of this sort could be made to yield the fullest practicable sum of work.

NICOLAS LEONARD SADI CARNOT

But all this was only a by-product of the splendid genius of Sadi Carnot. Lord Kelvin has said that in his opinion there is nothing greater in the whole extent of the domain of the sciences than the work of Sadi Carnot. To merit this remarkable praise from one of the later masters of modern knowledge, the young Frenchman must have done something more than found the theory of the steam-engine. And he did. He struck out, first in his book and then in his notes, the two fundamental laws of the new science of thermo-dynamics; and his idea of mechanical work is the point of departure in modern physics. The new science sprang full grown from his mind, but he had not sketched it out, nor completed his leading experiments, when he was cut off prematurely by cholera on August 24, 1832.

HENRY CAVENDISH

The First Man to Weigh the Earth

Henry Cavendish, the most eccentric of men and one of the most remarkable of chemists, was the grandson of the second Duke of Devonshire, and he was born at Nice, October 10, 1731. From a school at Hackney he went to Peterhouse, Cambridge, but after studying for three years at the university he left without a degree. An immense fortune, bequeathed to him by an uncle, enabled him to follow his own bent of mind; and for the rest of his life he was a cold, retiring, silent man, hating even the sight of a woman, and absorbed in scientific investigations. In his great house at Clapham Common any female servant he caught a glimpse of was dismissed. His splendid library was housed some four miles away in London, so that persons coming to consult it would not be met by him. He is estimated "to have uttered fewer words in the course of a life of fourscore years than any man who ever lived so long—not excepting the monks of La Trappe."

He was the most wealthy of learned men, and the most learned of wealthy men. At his death his fortune amounted to over a million sterling. He told his bankers he would take his money out of their hands if they continued to plague him about it. His house at Clapham was as strange as he was. What the builder intended for the drawing-room was the laboratory, and the next chamber was turned into a forge. The upper apartments were used as an astronomical observatory. Very little room was set apart for personal comfort. Mr. Cavendish rarely did violence to his passion for solitude by asking anyone to his house. But if anyone dined with him he got a leg of mutton, and nothing else. On one extraordinary occasion four guests were expected. "What shall I get for dinner, sir?" Cavendish replied with his unvarying formula, "A leg of mutton." "But that won't be enough for five!" exclaimed his man. "Then get two legs," was the answer.

Cavendish's eccentricities were largely due to a morbid shyness. He died, as he had lived, voluntarily severing every tie of human sympathy. Finding himself near his end, he called his servant to his bedside, and said, "Mind what I am going to say. I am going to die. When I am dead—but not till then—go to Lord George Cavendish, and tell him. Go!"

Cavendish wanted to die as he lived—in solitude. The servant hesitated to leave the room, but again was harshly ordered to do so. In half an hour he returned, and found his master had turned his face to the wall and died.

This strange, passionless, solitary man, whose emotions seemed to be quite dried up, had a marvellously clear intelligence. His published work was of the highest order, but it gave an incomplete idea of his powers. When the mass of notes he left behind him was published it was seen that he had been far in advance of the science of his time. "He strove with none, for none was worth the strife." Much of what seemed in him the wildest eccentricity was merely his method of assuring the freedom from little bothers and noise and social inanities that disturbed the silence in which his mind worked. One of our old writers contrasts the silence of an Archimedes in the study of a problem with the stillness of a sow at her wash, but many of the society dandies that laughed at the eccentric Mr. Cavendish could not distinguish between the two kinds of silence. For even the eighty years of life that Cavendish enjoyed seems too short for the accomplishing of his manifold and great achievements.

In heat and electricity he made discoveries that are commonly associated with the names of later men who had better appliances. He was a profound mathematician and a fine astronomer. When Berthelot declared that "Chemistry is a French science; its founder was Lavoisier of immortal memory," Sir Edward Thorpe justly replied, "Chemistry is an English

science; its founder was Cavendish of immortal memory."

Cavendish was the first man to weigh the earth. He established the proportions of the constituents of the air; he demonstrated the nature of water, and manufactured it from its elements; and he laid the foundation of the study of the laws of heat. Earth, air, fire, and water—each and all came under the range of his observation. This is surely a more remarkable fact than that he was a millionaire who did not care for money, and dined every day off a leg of mutton.

Cavendish was a natural philosopher in

HENRY CAVENDISH

the widest sense of the term, for he occupied himself in turn with every branch of physical science known in his time. But it is to his discoveries in chemistry that his fame is chiefly due. In his early inquiries he was influenced by the achievements of Black. He took up the study of carbonic acid gas at the point where Black left it, and ascertained it was one and a half times heavier than the common air. Then he experimented with the lighter hydrogen, and, by mixing it with oxygen, he made his great discovery of the composition of water. He took a large glass globe furnished with a brass cock and an apparatus for firing air by electricity. He exhausted the globe by means of an air-pump, and then filled it with a mixture of hydrogen and oxygen, and fired it with his electrical apparatus. After the explosion he admitted more of the two gases, and at the end of the sixth explosion he analysed the contents of the globe, and found that it contained water with an acid taste. He then traced the taste to the presence of nitric acid, due to the impurities of the gases used.

His discovery marked one of the great epochs in the history of chemistry. He showed that the most familiar of all liquids, which for thousands of years had been regarded as the supreme type of a fundamental chemical element, was composed of two colourless, invisible gases—one the inflammable hydrogen, the lightest of known substances; the other, oxygen, the life-sustaining principle in the air.

An ancestor of Cavendish's was one of the first men to sail round the earth. Cavendish himself was one of the first to attempt to weigh it. His apparatus consisted of a light, long wooden rod, suspended horizontally by a thin wire. At the ends of the rod were leaden balls, about 2 in. in diameter; and two large round masses of metal were so arranged that they could be brought close to the apparatus. By the mutual attraction of the big and little balls, the long rod was made slightly to move. The amount of the movement and the force necessary to produce it were observed by Cavendish, together with the weight of the balls, and the distances from their centres. He was then able to calculate what the density of the earth was in comparison with the density of a globe of water the same size. He worked it out that the earth is about five and a half times heavier than water, a result that later investigators, using more delicate and intricate appliances, have shown to be very near the truth. Cavendish died on March 10, 1810; and the Cavendish Laboratory at Cambridge, in which so much fine work has been done, was erected in his memory.

SIR WILLIAM CROOKES
The Story of a Wonderful Tube

Sir William Crookes, the eminent physicist, was born in London on June 17, 1832. After a course of study at the Royal College of Chemistry, where he became assistant to Hofmann, he passed to the superintendence of the meteorological department of the Radcliffe Observatory at Oxford. Later, he

accepted the post of lecturer on chemistry at the Science College, Chester. Before he was thirty he founded and edited a paper devoted to chemistry, and continued in control for half a century, while at the same time he edited the "Quarterly Journal of Science." From an early age he devoted his leisure to original experimental research, and the results have been of world-wide importance to science and the economy of daily life.

His first notable achievement was the discovery of a new element, which he named thallium; and while he was still working out the story of this metal, and determining its atomic weight and properties, he discovered the sodium amalgamation process for separating gold and silver from their ores. Pursuing his investigations as to thallium over a course of years, he presented to the Royal Society papers on "Repulsion from Radiation," which have had an important bearing on later scientific developments.

One result of his investigations led to the invention of the radiometer. This, in turn, brought him to investigations of the conduct of electric discharges through high vacua. He had been led thus far, through his experiments with thallium, on to his theory of repulsion resulting from radiation, from that to the radiometer, and thence to his famous vacuum tube—all this way simply from observing, in the first instance, that there remained in the spectrum of sulphuric acid a bright green not previously observed.

Now, for the purposes of examining discharges of electricity through highly rarefied gases, he was driven to invent higher vacua than had ever before been known. By greatly modifying the best air-pump in existence, he succeeded in reducing the air to one-millionth of an atmosphere. Although this was the highest vacuum ever reached with the air-pump, there still remained a comparatively large quantity of air in the vessel, so he fashioned a tube shaped like a dumb-bell, and sealed up at one end with a substance which greedily absorbs water vapour and different kinds of gases. This absorbing power increases rapidly with heat, so that, by means of his tube, he obtained a vacuum in which the air or gas was reduced to one twenty-millionth of an atmosphere. From this tube there proceeded developments which not even he could have foreseen.

The new tube gave us the electric light for the house and office. Electric lighting, save by the arc lamp, was impossible until Sir William Crookes invented his wonderful tube. France, which had already awarded him a special prize of 3000 francs and a gold medal in recognition of his discoveries in molecular physics and radiant matter, paid him a gratifying compliment when he went, by official invitation, to Paris, in 1881. to act as a juror at the International Exhibition of Electricity.

Among the exhibits were four systems of incandescent lamps, and Sir William, as a juror, was, of course, debarred from competing. The official report of his fellow-jurors, referring to the lamps exhibited, stated: "None of them would have succeeded had it not been for the extremely high vacua which Mr. Crookes has taught us to obtain."

But, apart from its economic value, the Crookes tube was instrumental in shattering the old conceptions as to the nature of matter. As is shown on page 1027 and succeeding chapters of this work, the whole fund of knowledge of radio-activity is practically derived from this invention. We should still have been in darkness upon that vast, fascinating subject but for the invention of this now universally adopted tube. The results to science and to humanity are set out in the pages mentioned, and need not be repeated in this place.

Not inspiration nor brilliant flashes of accurate guessing have led Sir William Crookes to his results. He has always been an untiring worker, and that in many fields simultaneously. While engaged in the most abstruse researches he was occupied in staying a cattle plague, in making daily tests of the Thames water used for human consumption, in elaborating schemes for the manufacture of beet sugar in England, in inventing new processes for dyeing and calico-printing, in observing solar eclipses, in writing or editing manuals on metallurgy, assaying, sewage disposal, and in isolating new and still newer rare earths and metals. He gleans where others have harvested in haste. Here is a fine message to his generation, as applicable today as it was when he uttered it thirty or more years ago:

"Residual phenomena are hints which may lead the man of disciplined mind and of finished manipulative skill to the discovery of new elements, of new laws, possibly of even new forces; upon undrilled men these possibilities are simply thrown away. The untrained physicist or chemist fails to catch these suggestive glimpses. If they appear under his hands, he ignores them, as the miners of old did the ores of cobalt and nickel."

THE POWERFUL TIDES DRAWN BY THE MOON

THE EFFECT OF THE MOON ON THE SEA IS PERHAPS MOST MARKED OF ALL IN THE POWERFUL TIDAL BORE OF FUNDY BAY, NOVA SCOTIA, WHERE THESE PICTURES WERE TAKEN.
An exhaustive study of the tides was the chief contribution of Sir George Darwin to astronomy

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ASTRONOMERS

JOHN COUCH ADAMS

The Man who Found Worlds by Mathematics

THIS profound mathematician, who shares with Leverrier the honour of the discovery of the planet Neptune, was born at Laneast, a village seven miles from Launceston, in Cornwall, on June 5, 1819. The son of a farmer, his interest in astronomy was early aroused by a collection of books on that science which his mother had inherited, and he began in boyhood to make observations of altitude with rude, home-made instruments. At school his genius for mathematics was unmistakable, and having entered St. John's College, Cambridge, in 1839, he graduated as Senior Wrangler in 1843. Already in 1841 he had determined to apply himself to the problem of the irregularities in the motion of the planet Uranus, being justly convinced that the study would lead to the discovery of the unknown body which was their cause.

The story of his magnificent success has been told in our consideration of the planet Neptune. But Adams did much great work quite apart from that. Of his many mathematical researches the most important are his investigations of the motion of the moon about the earth, and of the orbit of the Leonid meteors, which give rise to grand displays of shooting stars. In the former, following up the work of Halley and Laplace upon the same subject, Adams was able, in 1853, to establish the fact that the moon's journey round the earth is undergoing continuous acceleration, amounting to about six seconds in a century. His determination of the orbit of the meteors was completed in 1867. For honours, praise, detraction, controversy, Adams cared absolutely not at all, and was known as a humble and sincere man, of vast learning in a wide range of subjects. His work received abundant recognition, and from 1858 he was Lowndean Professor of Astronomy and Geometry at Cambridge, where he died on January 21, 1892. He was buried in St. Giles's Cemetery there, but a portrait medallion has been placed near Newton's grave in Westminster Abbey.

SIR GEORGE BIDDELL AIRY

The Man who Reorganised Greenwich Observatory

Born at Alnwick in Northumberland, on July 27, 1801, the son of an exciseman, and educated at Colchester Grammar School and Trinity College, Cambridge, Airy was distinguished throughout his academic career by a prodigious power of memory. All through his life, his success was due chiefly to his supreme business capacity; he was above all a practical man, caring nothing for abstract speculation. An exceptionally lucid mind and an almost exaggerated love of order combined to give him an extraordinary power of direction and management. The science of mathematics, of which he had a wonderful grasp, appealed to him chiefly as a "system of order." His interest in astronomy, which was first aroused in childhood by the gift of a pair of globes, brought him at the age of thirty-four to the responsible position of Astronomer Royal at Greenwich, where he kept most careful and minute records of observations, and made a point of publishing every detail of the work done. The Observatory had been most inefficient and in deplorable disorder when he took it in hand, but Airy

made it a model among institutions of the kind. It is to him that we owe the magnetic department of the Observatory, founded in 1838, and the spectroscopic department, initiated thirty years later. He was among the foremost in developing the application of photography to astronomical research, especially in the study of sunspots. Though his forty-six years of service at Greenwich were not marked by any sensational astronomical discoveries, the thorough work which he accomplished in the way of organisation and of record was more valuable to the science than any isolated results, however splendid, could have been. Airy was

SIR GEORGE BIDDELL AIRY

a great observer of eclipses of the sun, travelling to Italy for the eclipse of 1842, to Sweden in 1851, and to Spain in 1860. He thrice refused the honour of knighthood, but was at last created K.C.B. in 1872. He published over five hundred special papers, besides eleven volumes on mathematical and astronomical subjects. Airy died on January 2, 1892, and is buried in Playford churchyard. His story is told in his autobiography.

DOMINIQUE FRANÇOIS ARAGO

A Man who Faced Pirates to Extend Knowledge

Arago, a great French astronomer and physicist, was born on February 26, 1786, at Estagel, a little town north of the eastern end of the Pyrenees. His father was a lawyer and a considerable landowner. The boy longed for a military career, but his abilities brought him an appointment in 1804 on the staff of the Observatory, and he was sent in 1806, with Biot and two Spanish commissioners, to carry out geodetic surveys in the Balearic Islands. Their mission resulted in unexpected hardships and misadventures. Mistaken by the revolutionary Majorcans for a spy, Arago narrowly escaped in the disguise of a peasant, and, having reached Algiers, embarked for Marseilles. But his return was almost as laborious as that of Ulysses. A Spanish corsair captured the vessel in which he sailed; a period of imprisonment with merciless ill-treatment followed; and when set at liberty, and once more embarked for home, Arago was driven by tempest on to the African shore, three days' journey from Algiers. It was not until 1809 that he reached his native shore. He was received with acclamation, was elected a member of the Academy, though only twenty-three years old, and was appointed a professor at the Polytechnic School.

Although no ordinary discoverer, Arago was greatest as an interpreter of science. His lectures gave a life and a flavour to knowledge, which secured for it quite a new public, and initiated the era of popular interest in scientific matters. On the other hand, his studies in electro-magnetism were of great value, and he was the first to show the relation between the aurora and terrestrial magnetism. His investigation of light confirmed the theory, now universally accepted, that light consists of vibrations or undulations in the ether; and his invention of the polariscope was the beginning of a great advance in the science of optics. Appointed in 1830 perpetual secretary of the Academy of Science, Arago died on October 2, 1853. His "Autobiography," "Lectures," and "Popular Astronomy" have all appeared in English editions.

ARCHELAUS

The Man who First Denied the Flatness of the Earth

Early Greek philosophy, before the days of Socrates, was almost exclusively a fantastic and materialistic cosmology. But Anaxagoras of Clazomenæ, who settled in Athens about 456 B.C., and died in exile in 428 B.C., made a great advance when he realised that matter alone could not be the ultimate reality of the universe, but that Mind must be concerned in the ordering of the world. Among his pupils none was more distinguished than Archelaus, who was the first to deny, from direct observation,

the flatness of the earth, which had hitherto been generally taken for granted.

Archelaus had pondered upon the fact that the sun does not rise and set at the same moment in all latitudes, but that the day is longer in summer and shorter in winter in Northern regions than it is towards the south. Rightly perceiving that this inequality in the hours of sunrise and sunset at different latitudes was incompatible with a flat or plate-like form for the earth, he proceeded to the erroneous conclusion that the earth is not spherical, but hollowed out like a cup, being high at the rim and depressed at the centre. He could never have fallen into this mistake if he had known that the rising and setting of the sun are earlier in Eastern than in Western regions.

It is not worth while to enter into his other cosmological speculations, which were as wild and baseless as any which had preceeded them ; but it is worth noting that the demonstration, based on undeniable facts, that the earth could not possibly be flat, was not long in leading to a sounder hypothesis than any which Archelaus had been able to imagine. For there is no doubt that about this period the Pythagoreans began to entertain the true belief in the sphericity of our globe.

ARISTARCHUS

The Man who Found that the Earth Revolves

Aristarchus of Samos, a Greek philosopher who lived in the earlier part of the third century B.C., has the peculiar honour of having been the first to proclaim the orbital motion of the earth round the sun, thus forsaking a geocentric for the heliocentric view of the solar system. His predecessor, Herakleides, had discovered the rotation of the earth about its own axis, and had described also the heliocentric orbital movements of Mercury and Venus, but had failed to conceive of our globe as pursuing a progressive movement round the sun. The illustrious Archimedes, by far the greatest mathematician and mechanician of the ancient world, was a contemporary of Aristarchus, to whose theory he refers in the following terms :

" He supposed that the fixed stars and the sun are immovable, but that the earth is carried round the sun in a circle." Plutarch again remarks that Aristarchus believed " that the heavens stand still and the earth moves in an oblique circle at the same time as it turns round its own axis." Seleukus, a Babylonian, who lived about 150 B.C., followed Aristarchus in the belief in the daily rotation of the earth, if not in its annual journey round the sun, but at that point the conception of the earth's orbital movement disappeared from the mind of man for seventeen hundred years. There is little doubt that in his own time, and by the immediately succeeding generations of astronomers, the bold conception by which Aristarchus anticipated Copernicus was received with general incredulity, if not with horror on account of its impiety.

Little is known of Aristarchus, and his one book which has come down to us, " On the dimensions and distances of the sun and moon," contains no reference to the lofty generalisation for which he is now most famous. His attempt to estimate the distances of the greater and the lesser light resulted in the erroneous conclusion that the sun is about eighteen or twenty times as far from us as the moon is. But it was based upon serious observation and calculation, for Aristarchus was far ahead of his time.

DOMINIQUE FRANÇOIS ARAGO

JEAN SYLVAIN BAILLY

A Deserter from Astronomy to Politics who was Beheaded

Born in Paris, on September 15, 1736, Bailly attempted in turn the arts of the painter, poet, and dramatist, but was not long in finding his true vocation as an astronomer. An account of his observations on the moon, presented to the Academy of Sciences, procured for him, in 1763, the rank of an academician. Thenceforward he

specialised on the study of the satellites of the planet Jupiter, and was able in 1766 to publish a table of their motions, and later an investigation of their variations in brilliancy according to their position with regard to Jupiter and the position of Jupiter relatively to the sun and the earth. But literary work had still a great attraction for him, and he gradually forsook the observatory in order to compile a brilliant and comprehensive, but not always accurate, History of Astronomy, 1775 to 1782.

With this work his career as an astronomer came to an end. Bailly was caught up into the storms of the French Revolution, and, after enjoying enormous popularity in 1789 as first President of the States General and Mayor of Paris, he quickly declined from public favour. Having excited the hatred of the mob by his fearless condemnation of their false accusations against the Queen on her trial, he was arrested in July, 1793, and executed on November 12 of the same year. His own "Mémoires d'un Témoin de la Révolution" is an interesting study of those turbulent years. His astronomical labours, though very limited in amount, were of great value to science.

FRANCIS BAILY

The Man who Proved the Roughness of the Moon

It will be remembered that during an eclipse of the sun the last view that we get of the disappearing edge of the sun's disc, and the first view that we get of its reappearance on the other side of the moon, are in the form of a crescentric series of separate points or beads of light. This phenomenon, supposed to be due to irregularities of the surface of the intervening moon, is known as Baily's Beads, being called after its first observer, Francis Baily. Born at Newbury, in Berkshire, on April 28, 1774, the son of a banker, Baily became a London stockbroker, and distinguished himself in that career. But his services to astronomy give him considerable rank among English men of science. He was first attracted to the study of the heavens when writing an "Epitome of Universal History," published in 1813, having made, for the purposes of this book, a mathematical computation of the solar eclipse which was predicted by Thales, the early Greek philosopher. Baily was one of the founders of the Astronomical Society, which was constituted at the Freemasons' Tavern, on January 12, 1820; he was the first secretary of the society, and had much to do with framing its constitution. We have already alluded to his well-known discovery during the annular eclipse of the sun on May 15, 1836. This, however, was not his most important astronomical work. His skill in computation and extreme thoroughness in detail gave great value to his labours on star catalogues. He revised the catalogues of Ptolemy, Tycho Brahe, Halley, Hevelius, Flamsteed, Lacaille, and Mayer, an undertaking which entailed an enormous amount of work. Each star was calculated with such care that Baily detected errors which had escaped many previous students. He also wrote an admirable Life of Flamsteed. He died in London on August 30, 1844.

SIR ROBERT BALL

A Famous Student and Great Populariser of Astronomy

Sir Robert Stawell Ball was born in Dublin on July 1, 1840, son of the well-known naturalist Dr. Robert Ball. He was educated at Abbott's Grange, Chester, and Trinity College, Dublin, and in 1865 was invited to take charge of Lord Rosse's giant reflector at Parsonstown, where many interesting observations were made and much valuable work done, especially in relation to nebulæ.

In 1867 he was appointed to the Chair of Applied Mathematics and Mechanism in the Royal College of Science for Ireland; in 1874 was appointed Andrews Professor of Astronomy at Dublin University, and Director of Dunsink Observatory. From 1874 to 1892 he held the position of Royal Astronomer for Ireland. At Dunsink Professor Ball gave much time to the search for stellar parallax. He tested Nova Cygni for parallax, and determined that this new star must be at least twenty million millions of miles distant. He made a sweeping examination of the heavens for stars with measurable parallaxes, and determined those of 1618 Groombridge and of 61 Cygni.

In 1874 Professor Ball began his career as public lecturer, since which date he has lectured with great success in almost every important town of Great Britain and Ireland, as well as in Philadelphia and Boston. He received, in 1886, the honour of knighthood, and in 1892 was appointed to his present position as Lowndean Professor of Astronomy and Geometry at Cambridge. He has been at different times president of the Royal Astronomical Society and of the Mathematical Association.

Sir Robert Ball, who is an extremely able and popular writer, has published a large number of books on astronomical

SIR ROBERT BALL LOOKING AT THE HEAVENS FROM THE OBSERVATORY AT CAMBRIDGE

subjects, which have had an unusually wide circulation. Among these may be mentioned: "A Treatise on Spherical Astronomy," "The Story of the Heavens," "Starland," "In Starry Realms," "In the High Heavens," "Atlas of Astronomy," "The Story of the Sun," "The Cause of an Ice Age," "Great Astronomers," "The Earth's Beginning," and a "Guide to the Heavens."

Sir Robert Ball is a supporter of the nebular theory of the universe, but holds that the nebula from which the solar system took its rise was a small one, comparable rather to the planetary nebulæ than to any of the great nebulæ, and that the formation of the solar system was due to the condensation of the primary nebula as it gave out its enormous initial heat. The sun and planets represent, under this theory, one large and several smaller centres of concentration of the primary nebula.

EDWARD EMERSON BARNARD
Who Has Managed the World's Biggest Telescopes

One of the greatest living telescopic discoverers, Professor Barnard was born at Nashville, Tennessee, U.S.A., on December 16, 1857. His earliest astronomical studies were undertaken alone, but as early as 1883 we find him in charge of the observatory at Vanderbilt University, which position he held until 1887. From that year until 1895 he was in charge of the famous Lick Observatory of the University of California; and his observations with the great telescope in its extremely advantageous position at Mount Hamilton have been of the highest astronomical value, especially in the investigation of the lunar "seas," which were clearly proved to be incompatible with the idea of real seas of water; in the study of Saturn's rings; and in the discovery of comets and nebulæ. His photographs of celestial objects. and especially of nebulæ, of comets, and of many regions of the Milky Way, have added greatly to knowledge of the heavens, and many of these have been reproduced in the pages of POPULAR SCIENCE by his courteous permission.

Since 1895 Professor Barnard has been in charge of the Yerkes Observatory of the University of Chicago, and Professor of Practical Astronomy in that university. He is thus connected with the two most

famous American observatories, and with two of the largest telescopes in the world. Professor Barnard has discovered the fifth satellite of Jupiter, sixteen comets, and many nebulæ; he discovered that Beta Capricornis is a double star; and has made many other contributions to science. He has received honours and awards from many scientific bodies, including the Lalande gold medal and Arago gold medal of the French Academy of Sciences, and the Janssen prize of the French Astronomical Society.

JOHANN BAYER
A Man who Made Over Fifty Star-Maps

Johann Bayer was born at Rain, in Bavaria, in the latter part of the sixteenth century, probably about 1572. Educated in the principles of the Lutheran Church, he became widely known as a bold and eloquent speaker, and received the nickname of *Os Protestantium*—the "Mouthpiece of Protestants." He was for many years prominent in the life of Augsburg. He was also a very zealous astronomer, rendered a particularly useful service to the science, and received for his labours a title of nobility from the Emperor.

ALEXANDER WILLIAM BICKERTON

It was in 1603 that Bayer brought out the work for which he is famous, entitled "Uranometria," or "Measurement of the Heavens." This contains descriptions of the constellations and fifty-one elaborate star-charts. Its distinguishing characteristic is that here, for the first time, the stars in each constellation are separately designated by the letters of the Greek alphabet, and, when these have been exhausted, by the letters of the Latin alphabet. The method was at once found extremely convenient, and is in use at the present day. The descriptions of the constellations are clear and the maps are fairly accurate. The latter retain the old figures of animals, heroes, and other symbols by which the constellations have been denoted from antiquity. It has been noticed that in many constellations the brightest star is denoted by the letter beta, or some later letter of the alphabet, instead of by alpha, and this was formerly thought to show that the stars had changed in relative brightness; but Argelander pointed out that Bayer began his lettering with the chief stars of a constellation in their order from north to south, and not in their precise order of brilliancy. Bayer's catalogues are still of value, though his work preceded the invention of the telescope. He died in 1660.

A. W. BICKERTON
The Man who Declares that the Universe is Ever Renewing its Youth

Professor Alexander William Bickerton, the originator of the ingenious "impact" theory of cosmic evolution (see page 1498), which is also sometimes referred to as "the new astronomy," was born at Alton, in Hampshire, on January 7, 1842. Educated first at the Alton Grammar School, he passed brilliantly through the Royal College of Chemistry, and was senior royal scholar of the Royal School of Mines. Although trained as an engineer, he was led to devote himself exclusively to scientific research. Mr. Bickerton early made his mark as an educational organiser, originating in 1867, under South Kensington, the London Technical Classes, which were the germ of the present vast development of popular technical education in the metropolis. This success led to his appointment as organiser of the science classes at the Hartley Institution, Southampton, and this new department proved so efficient in preparing for the Indian science service that the Indian Board decided to make the Hartley its Technical Training College. This arrangement was, however, prevented by the establishment of Cooper's Hill College. Mr. Bickerton then decided to leave England, and, of several appointments which were offered, accepted a chair of chemistry in New Zealand, which he held for nearly thirty years.

Having arrived, in 1878, at the astronomical theory of "partial impact," as described

in the third and thirteenth chapters of the present work, Professor Bickerton wrote several volumes on the subject and published his theory widely by means of lectures and articles. His views were long neglected by scientific authorities, but a sudden reversion of opinion at last set in. Sir George Grey, Premier and former Governor of New Zealand, lent his influence, and funds were voted in the House of Representatives to send Professor Bickerton to England, where he has forcibly advocated his generalisation, claiming that the theory "shows that the entire scheme of things is cyclic, in which there is birth, maturity, decay, and rejuvenescence in planets, suns, and sidereal systems, as well as in organic life, the cosmic whole being infinite, immortal, and flawless, without evidence of a beginning or promise of an end." The theory of partial impact has received much confirmation.

JEAN BAPTISTE BIOT

One of the Great Experts in Studying Light

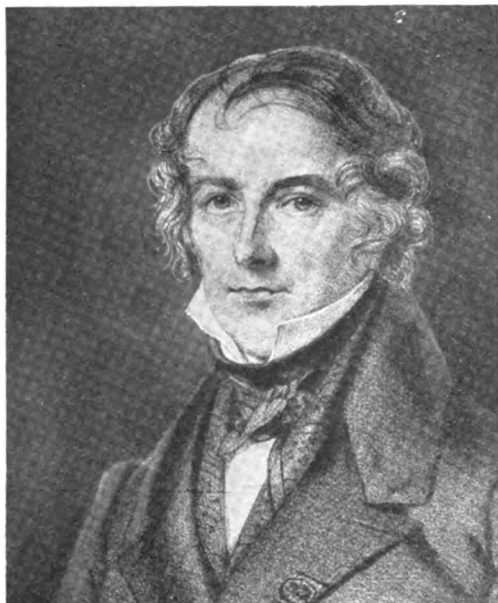
This eminent French scientist, born in Paris on April 21, 1774, was educated for the Army, and served in the artillery, but was led by scientific interest to leave the Service and return to study at the Polytechnic School. In 1800, though only twenty-six years of age, he was appointed to the Chair of Physics in Paris. He applied to Laplace for permission to read the proofs of his "Mécanique Céleste," and the introduction thus effected was the beginning of a close friendship which was very advantageous to both. Biot published in 1801 an "Analysis" of the great work of Laplace. An unprecedented shower of meteors having fallen at L'Aigle, in Normandy, on April 26, 1803, Biot was sent by the Government to investigate the phenomenon; and in the same year he was associated in the study of gases with Arago and Gay-Lussac. In 1804 he accompanied the latter in his first balloon ascent, and was sent with Arago to Spain, two years later, for the purpose of measuring an arc of the meridian.

His most important work was connected with the study of optics. His laborious and ingenious researches on the subjects of the polarisation of light and of double refraction are embodied in many papers contributed to the Academy of Sciences. The most valuable discovery which he made was that of the rotatory action of fluids upon light. In 1817 Biot visited England and Scotland for the purpose of further meridional observations, carried on chiefly in the Orkneys. He died on February 3, 1862.

WILLIAM CRANCH BOND

A Watchmaker who Found Seventeen Comets

William Cranch Bond, the pioneer astronomer of Harvard, was born at Portland, Maine, U.S.A., on September 9, 1789. His father being a watchmaker, he was educated to this trade, but in 1806 an eclipse of the sun confirmed his leaning towards astronomy, and from that time forth every spare moment was devoted to the study of the heavens. He built at his home one of the first private observatories in America.

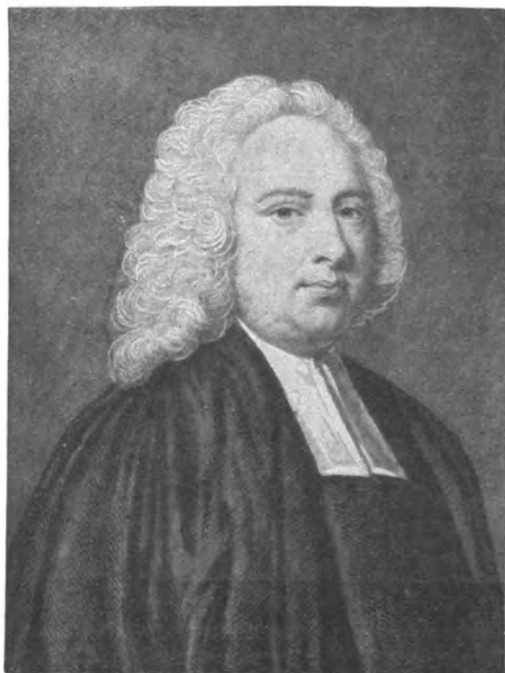
In 1815 he was commissioned by Harvard University to visit the chief observatories of Europe in order to prepare designs for the new observatory which the premier univer-

JEAN BAPTISTE BIOT

sity of America was about to establish at Cambridge. The opening of this observatory was delayed for many years owing to lack of funds, but an excellent telescope was at last erected in 1847. With this instrument the discoveries of Bond and his son were very numerous and of first-class importance. They included the discovery of the inner dusky ring of Saturn, and much information as to the nature of the outer rings; the discovery of the eighth satellite of Saturn, as well as of Neptune's satellite, the latter discovery allowing of the determination of the mass of the planet Neptune himself. Seventeen new comets were also described by the Bonds.

Bond was one of the first astronomers to adopt photographic methods in the study of celestial phenomena, and by

means of the camera made valuable observations of the sun, moon, and stars. With their great telescope the Bonds were the first to succeed in resolving the Orion and the Dumb-bell nebulæ. They also were the first to compute the distances and angles of the stars in the Hercules cluster. The father died January 29, 1859.

JAMES BRADLEY
An Astronomer Royal who Watched the Stars from Boyhood

James Bradley, discoverer of the aberration of light, and by some authorities ranked as an astronomer with Hipparchus and Tycho Brahe, was born at Sherborne, in Gloucestershire, in March 1693. He was educated at Northleach Grammar School

JAMES BRADLEY

and Balliol College, Oxford. It was not, however, at school or college that he learned to love astronomy, but from an uncle, the Rev. James Pound. This uncle was a failure as the world counts failure, but a most lovable man, who had acquired a skill in astronomical observation which was unrivalled in his day, so that even Halley, then Astronomer Royal, and other great astronomers, used to apply to him for measurements and other data. Pound cherished a warm affection for his nephew, and kept him at his side until his death, in 1724. Together they carried on the scrutiny of the heavens, and optical experiments in the laboratory, with the result that Bradley became one of the ablest living observers.

James Bradley's genius was marked by the unusual combination of the most scrupulous accuracy with that power of wide, far-reaching generalisation which finds in the smallest details the working of universal principles. His momentous discoveries of the aberration of light, and of the nutation or "nodding" of the earth's axis, would alone suffice to perpetuate his fame among astronomers of all time. The fact that, after puzzling over his problem for years, he finally obtained the clue to it from seeing the movements of a vane at the masthead of a sailing-boat tacking up the Thames, is significant of his receptiveness and alertness.

Having taken Orders in 1719, Bradley held for two years the living of Bridstow, in Herefordshire, but relinquished ecclesiastical work when appointed, in 1721, Savilian Professor at Oxford. The duties of his Chair were not exacting; and as Oxford at that time possessed no observatory of any kind, he continued to spend the greater part of his time with his uncle at Wanstead, studying the stars. The old man's death deprived James Bradley of much more than a dear relative, but he continued to use his uncle's observatory until he joined Molyneux, who had set up a telescope at Kew. The two then addressed themselves to the search for stellar parallax, and it was during the course of these observations that Bradley was led to the discovery of the aberration of light. This he gave to the world by means of a letter to Halley, written towards the end of 1728, and read before the Royal Society on January 9 and 16, 1729. Bradley's "constant of aberration" remains, with only very slight modifications, that which is accepted by astronomers of the present day.

This discovery led him on to his second great achievement. With characteristic exactness, Bradley discovered that after allowing for aberration there still remained a cyclical variation which was due neither to aberration nor to parallax; and finding that this variation was constant for all stars, and that it agreed in its cycle with the period of revolution of the moon's nodes, he went on to the discovery of the principle of nutation, or deviation of the earth's axis. The latter discovery was announced in 1748.

In the meantime, Bradley had been appointed Astronomer Royal in succession to Halley, who died in 1742. He found the

observatory at Greenwich in a state of shocking neglect, many of the instruments being out of date and others out of order, for Halley's taste had lain not so much in the direction of observation as in that of the elucidation of large mathematical principles. The new chief, with the help of his nephew, John Bradley, soon got the place into working order, and uncle and nephew carried out there together an extraordinary amount of most valuable observational work. Bradley had with some difficulty obtained the sum of £1000, which was spent in equipping the observatory with a mural quadrant—still to be seen in its original position—and other necessary instruments.

Further important labours which Bradley carried out can only be mentioned very briefly. He computed the orbits of several comets at a time when these determinations were a novelty, for the periodic return of comets had been only recently discovered by Halley. He added considerably to our knowledge of the revolutions of the satellites of Jupiter, and by his regular and incomparably skilful observations of the sun, moon, planets, and stars supplied a basis for the determination of astronomical constants, from which Bessel prepared his great work "Fundamenta Astronomiæ."

In 1748 Bradley received the Copley medal of the Royal Society, and honours of all kinds were showered upon him. He was made a member of learned societies all over Europe. He died on July 13, 1762, and was buried at Minchinhampton.

TYCHO BRAHE

A Great Astronomer who Would Not Believe the Earth Goes Round the Sun

On December 14, 1546, three years after the death of Copernicus, and sixty-three years before Galileo's invention of the telescope, the great Danish astronomer Tycho Brahe was born, of a noble family, at Knudstrup, his father's estate in the south of Sweden, which at that time was a province of Denmark. Tyge—for that was his real name—was the son and heir of a privy councillor who held high offices of State, but at the age of one year the infant was kidnapped by a wealthy, childless uncle, an admiral, who longed for a boy to bring up as his own. Tycho's parents were soon reconciled to the arrangement, and the boy received an excellent education, proceeding to the universities of Copenhagen and then of Leipzig, in order to qualify for the political career to which his guardian had devoted him. But Tycho's affections were soon called to the starry heavens, from which they never returned. An eclipse of the sun, on August 21, 1560, was the beginning of his astronomical career. He had already dipped into astrology, and played with its fanciful predictions, but the scientific knowledge which could foretell the precise moment of the eclipse impressed him as no less than divine. Under every discouragement the boy studied the sky when his tutor was asleep, and by the age of sixteen had arrived at far-reaching conclusions which were soon to revolutionise the science. Kepler, his great successor, has recorded that "the restoration of astronomy by that phœnix of astronomers, Tycho, was first conceived and determined on in the year 1564." His leading idea was an unremitting course of the most accurate possible observations, in order to reveal the nature of planetary motions and the structure of the solar system.

TYCHO BRAHE

After residence at the universities of Wittenberg and Rostock, which were seething with the revival of science, Tycho settled at Augsburg, where he constructed a huge quadrant, of nineteen feet radius; and after the death of his father, in 1571, he removed to Heridsvad Abbey, near Helsingborg, formerly a monastery, but now the home of an uncle. Experiments in alchemy had begun to distract him,

when an astounding celestial portent recalled him to a life-long devotion. He was in his twenty-seventh year when, on November 11, 1572, returning from the laboratory to the house for supper, he was aware of an excessively brilliant star in Cassiopeia, where none had been known before. For eighteen months, as the new star declined in brightness, he continued to study it ; and having written an account of it, under the title "De Nova Stella," was persuaded at last to publish it, for he was held back by the prejudice that it was improper for a nobleman to write books. The little volume, now very rare, besides astronomical facts, contains much grandiose moralising in Latin verse, and predictions of "wars, seditions, captivity, and death of princes and destruction of cities, together with dryness and fiery meteors in the air, pestilence, and venomous snakes." Strange amalgam of science and nonsense !

Improper as it was for a nobleman to turn astronomer and write books, it was worse to take a peasant girl for his comrade, and worst of all that the legitimacy of their children was at least doubtful. Tycho was hopelessly improper, and was besides of an exceedingly arrogant and overbearing temper, so that he soon found it desirable to live elsewhere than among his own people. King Frederick II., however, unwilling to lose so rare an ornament to his country, persuaded the fastidious astronomer to accept the gift of an island, together with means to build a home and observatory. So it was on the island of Hveen, protected by the waters of the Sound from social impertinence, that Tycho Brahe carried out most of his life's work. Complicated difficulties, due chiefly to his own fault, drove him from the island in 1597. He left Denmark for ever, and, after an unsettled interval, he found protection and a salary from the German Emperor, Rudolph II., who also gave him for a home the royal castle of Benatky, twenty-two miles north-east of Prague. Here Johann Kepler, whose fame was ultimately to be no less than that of Brahe himself, joined him in 1600, as one of his several assistants ; and in the same year Tycho removed, with his instruments, to the city of Prague. He died on October 24, 1601, and was buried in the Teynkirche, having left to Kepler the enormous records of his observations.

Tycho Brahe was indeed "a king among astronomers." His unrelenting mind carried forward the boundaries of the science in every one of its provinces, initiating that deliberate and sanguine campaign of investigation of which no one can foresee the end. Nevertheless, he was a man of his time. He was in the habit, for instance, of casting the horoscopes of his friends, and some of these were fulfilled in detail with astonishing accuracy.

He was impeded by a too literal deference to the words of Scripture, as well as by a too easy acceptance of popular prejudices, so that although the great work of Copernicus was famous before he was born, Tycho Brahe maintained to the end that the earth was at rest, the fixed centre of the physical universe. His own system (for he rejected the Ptolemaic equally with the Copernican) came to him "as if by inspiration," in 1583. Dr. Dreyer, Brahe's biographer, represents it as follows. "The earth is the centre of the universe, and the centre of the orbits of the moon and the sun, as well as of the sphere of the fixed stars, which latter revolves round it in twenty-four hours, carrying all the planets with it. The sun is the centre of the orbits of the five planets, of which Mercury and Venus move in orbits whose radii are smaller than that of the solar orbit, while the orbits of Mars, Jupiter, and Saturn encircle the earth." Dr. Dreyer remarks that "this system is in reality absolutely identical with the system of Copernicus, and all computations of the places of planets are the same for the two systems," yet the fact that Brahe was kept, by really puerile considerations, from accepting the conclusions of his great predecessor is one of the puzzles of that wayward instrument the human mind.

Tycho Brahe's positive achievements were of vast extent and variety, and coupled with his princely way of life on the island gave him an immense and somewhat mysterious reputation. In the first place, he was a very ingenious inventor and improver of astronomical instruments and methods of observation, owing to his passion for minute accuracy, for before his time observations had been comparatively casual in character. Beginning as a boy with a simple pair of compasses, held out at arm's length, to measure the distances between stars, he elaborated, as the years went on, instruments far more efficient than had been known before, and published in 1598 a folio volume, "Mechanica," illustrated by woodcuts of his equatorial armillæ, quadrants, sextants, and other apparatus. One of his minor but most useful devices was the invention of "transversals," to increase the

minuteness with which a position on the arc of an instrument may be read. This is but one example of countless ingenious contrivances that have come down to us from the island workshops, where many skilled hands carried out the ideas of the master. Even Tycho's books were set up and printed under his own supervision.

Of all his astronomical labours, perhaps his great catalogue of the positions of over one thousand fixed stars was the most ambitious. No considerable advance in mapping the skies had been made since Ptolemy's catalogue, which had been made fourteen centuries before, and was perhaps little more than a compilation from the yet more

GIOVANNI DOMENICO CASSINI

ancient observations of Hipparchus. Having determined with the utmost possible accuracy the positions of a few standard stars, Tycho measured the positions of all the others in relation to these; and although his results have, of course, been superseded by the far more accurate and extensive labours of modern observatories, he established a solid basis for astronomical research that was of the greatest value to his successors. In his book on the great comet of 1577, which he boldly entitled "Introduction to the New Astronomy," he not only demonstrated the fact, previously uncertain, that comets are celestial bodies, and not atmospheric phenomena of some kind, but also speculated profoundly, though often erroneously, upon the structure of the heavens. His studies also included determinations of the complex movements of the moon, of the solar parallax, of refraction, and especially of the movements of the planets—the subject which most deeply interested him from boyhood to the day of his death. But the actual determination of the planetary orbits was reserved for his loyal assistant and constant admirer, Kepler.

GIOVANNI DOMENICO CASSINI

A Man who "Wrote His Name on Saturn"

Cassini, one of the greatest of the early telescopic observers, and an all-round astronomer of much power, was born on June 8, 1625, at Perinaldo, near Nice. Having studied under the Jesuits at Genoa, he was appointed, at the age of twenty-five years, professor of astronomy at Bologna, the most illustrious of Italian universities. His great reputation, gained chiefly by his studies of the planets and their satellites, secured for him appointment as the first director of the newly established Observatory of Paris, and in 1673 he was naturalised a French subject. For four generations the family of Cassini succeeded one another in this distinguished office. Most of Cassini's important observations were made in France, though his calculation of the period of Jupiter's rotation and his observations of the transits of the giant planet's satellites, as well as his determinations of the rotation periods of Mars and Venus, belong to his earlier life at Bologna.

Cassini's discoveries were numerous because he worked in a field which was still comparatively new to telescopic research. They include four of Saturn's satellites, only one satellite having been ascribed to this planet before his time; the discovery of the double character of Saturn's rings, the belt being divided by what came to be known as "Cassini's division," and the eighth satellite of Jupiter, known as Iapetus. The Saturnian moons were discovered between 1671 and 1684, Iapetus in 1671, and the division between Saturn's rings in 1675.

But Cassini carried out also many other important works, including a most laborious and accurate chart of the surface of the moon, showing the craters, seas, rills, rays, mountains, etc., as clearly as was possible with the instruments of his time; tables of Jupiter's satellites and their revolutions round the planet; the elaboration of a complete theory of the laws of variation of the moon's axis, approximating very

nearly to the values now ascertained; and the completion of the meridional line from Paris to Rousillon. It was chiefly at Cassini's instigation that the famous expedition was sent out to Cayenne, which succeeded in establishing the fact that gravity decreases in value from the Poles to the Equator, so that the same object is heavier in higher latitudes than it is in lower latitudes. He was one of the earliest observers of the zodiacal light, and also one of the first to measure the sun's parallax. He died at the Observatory of Paris on September 11, 1712.

SIR WILLIAM CHRISTIE

Astronomer Royal and a Great Maker of Star Maps

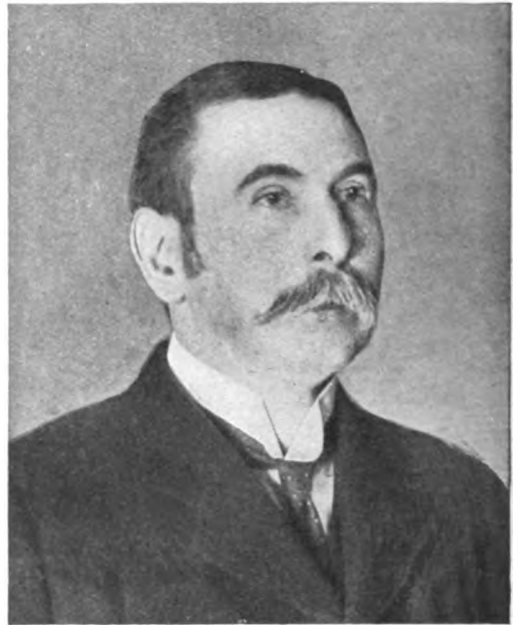
Sir William Christie, the late Astronomer Royal and Director of the Greenwich Observatory, was the eighth to hold that office since its foundation in 1675. The appointment is made by the Prime Minister in power when it falls vacant, and is held by warrant under the Royal sign manual. Sir William Christie is grandson of James Christie, founder of "Christie's," and son of the late Samuel Hunter Christie, professor of mathematics at Woolwich Military Academy, and a well-known student of the conductivity of metals, and of the influence of temperature on the magnetic needle.

Born at Woolwich, in 1845, Sir William Christie was educated at King's College School, whence he proceeded to Trinity College, Cambridge, and graduated there in 1868, being Fourth Wrangler. Two years later he joined the staff of the Royal Greenwich Observatory as chief assistant to Sir G. B. Airy, whom he succeeded as Astronomer Royal in 1881. During his tenure of office until 1910 the work done at the observatory increased enormously, and the organisation and administration of this great astronomical centre was a task requiring exceptional powers and energy. Sir William Christie has published many papers on various astronomical subjects in the "Proceedings of the Royal Society," and has revised Groombridge's Circumpolar Catalogue.

AGNES MARY CLERKE

A Lady who Could Make Astronomy Plain

Agnes Mary Clerke was born at Skibbereen, county Cork, on February 10, 1842. Her father was a bank manager, and from him she inherited her taste for astronomy. She studied astronomy from the age of twelve, and, though never a practical astronomer, obtained such a clear and comprehensive understanding of the subject as gives to her books an exceptional value. Added to this, they are written in a popular, lucid, and simple style, making the difficult scientific problems of interest to the general reader.

Between 1867 and 1877 Miss Clerke and her sister resided in Italy, chiefly in Florence; and during this time her first astronomical essay was written—a paper called "Copernicus in Italy." It was printed in the "Edinburgh Review," April, 1877. In 1877 the family settled in London. In 1888, on the invitation of Sir David and Lady Gill, she went to South

SIR WILLIAM CHRISTIE

Africa, and spent three months at the Cape Observatory, where a telescope and a spectroscope were set apart for her use; and during this visit she made considerable observations of various stars.

Her most important books, all three of which have become standard works, are: "A Popular History of Astronomy in the Nineteenth Century," published 1885 (last edition, 1902); "The System of the Stars," published 1890 (second edition, 1905); and "Problems in Astrophysics," published 1903. Other smaller books are: "The Herschels and Modern Astronomy" (1895), "Astronomy" (1898), "Modern Cosmogonies" (1905). She also contributed many papers to the "Observatory Magazine."

In 1892 she was awarded the Actonian

prize of a hundred guineas for her writings. In 1903 she was elected honorary member of the Royal Astronomical Society. She died at South Kensington on January 20, 1907.

NICOLAS COPERNICUS

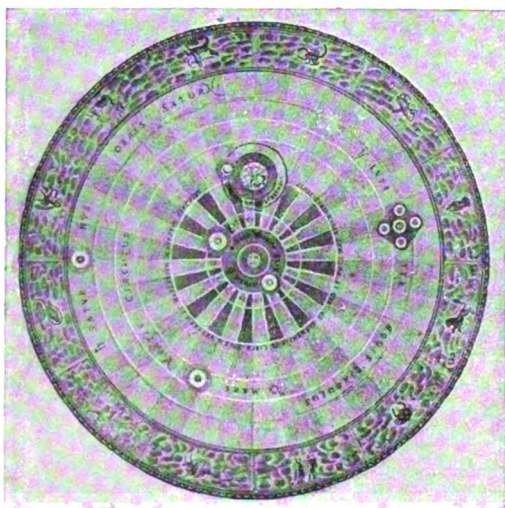
A Modest Pole who Rediscovered the Earth's Rotation

Aristarchus, the ancient Greek philosopher, had recognised that the daily rotation of the earth, and its orbital journey round the sun, afforded the simplest explanation of the apparent movements of the starry heavens. His pronouncement was, however, rejected by his contemporaries and successors, and the central fact of astronomy lay hidden in oblivion for seventeen centuries, until rediscovered by Niklas Koppernigk, who was born near the shores of the Baltic on February 19, 1473.

Copernicus—for we shall keep to the Latin form of his name—was the son of a wealthy merchant at Thorn, on the banks of the Vistula. He proceeded at the age of eighteen years to the University of Cracow, where he was taught the Ptolemaic astronomy which had so long reigned unquestioned; and in 1496 entered on a long course of various studies at the most famous Italian universities—Bologna, Rome, Padua, Ferrara. He returned to his Northern home in 1506, probably with a universal grasp of the knowledge of his time.

All this was, of course, at a period of extraordinary intellectual and spiritual fervour. Almost simultaneously, scholars had discovered the ancient world, and mariners and adventurers the new; and the change which Copernicus experienced from the low, cold, misty plains of the Baltic to sunny and opulent Italy, then at the height of her splendour, would be to him hardly distinguishable from that tremendous historic liberation by which the human spirit became once more aware of the majesty and wealth of its earthly home. Having seen men and cities, and educated with a width and depth for which our modern specialised learning is perhaps a poor substitute, Copernicus, Doctor of Canon Law, and appointed a canon of the cathedral at Frauenburg, on the Baltic coast, took up his principal residence in that city for the rest of his life, and won an enviable reputation as an administrator, judge, physician, and social reformer. With all that side of his life, honourable as it was, we are not here concerned, but we may regret the days when the world's great men were all-round men, and therefore so much the greater.

During the thirty-seven years from his establishment at Frauenburg until his death on May 24, 1543, Copernicus was absorbed in the profoundest problems of astronomy, and, notwithstanding his reticence and modesty, was early known as an authority on that science, so that his opinion was invited when the reform of the calendar was under review by the Lateran Council in 1514.

He made many astronomical observations, directed chiefly to the more accurate determination of planetary orbits and of eclipses of the sun and moon, but his work lay rather in meditation and calculation than in observation. He became more and more impressed by the intolerable complexity of the movements which the Ptolemaic system inevitably ascribed to the planets, and came to the conclusion that all these

COPERNICUS'S SYSTEM OF THE UNIVERSE

incredible complications must be due to some radical error in the way which men sought to understand these orbital motions.

With this problem in his mind, he found references in the works both of Cicero and of Plutarch to an ancient conjecture that the earth itself might be in motion, and in testing that hypothesis found that a daily rotation of the earth on its own axis, and its annual revolution round the sun, were in themselves sufficient to account for the spinning of the heavens round the Poles, and the apparently perverse anomalies in the course of the planets.

"And thus," he wrote in the dedication of his great work, "after long and careful observation, I have found that when the movements of the other planets are referred to the circulation of the earth, and are

computed for the revolution of each star, not only do the phenomena necessarily follow therefrom, but the order and magnitude of the stars, and all their orbs, and the heaven itself, are so connected that in no part can anything be transposed without confusion to the rest and to the universe."

NICOLAS COPERNICUS

Copernicus incorporated his theory in a work, entitled "De Revolutionibus Orbium Cœlestium," of which the manuscript was completed in 1530. It was not, however, published until 1543, and Copernicus received the first printed copy on the day of his death. The work was dedicated to a Pope, and a cardinal had long urged its publication, but the reluctant author had held it back for years, dreading the popular clamour which his bold speculations were sure to arouse. Its advent was heralded, however, by a short summary of the system, prepared by Copernicus and circulated in manuscript, as well as by a book written by Rheticus, an enthusiastic disciple, and published in 1540.

Dr. Dreyer, the historian of planetary systems, sums up the contribution of Copernicus to knowledge in the following words. "Copernicus not only showed that the assumption of the annual motion of the earth round the sun would explain in a very simple manner the most glaring irregularities in the motions of the planets, but he built up a complete system of astronomy thereon, a system capable of being further developed as soon as an indefatigable observer had perceived the necessity of cross-examining the heavens in a persevering manner."

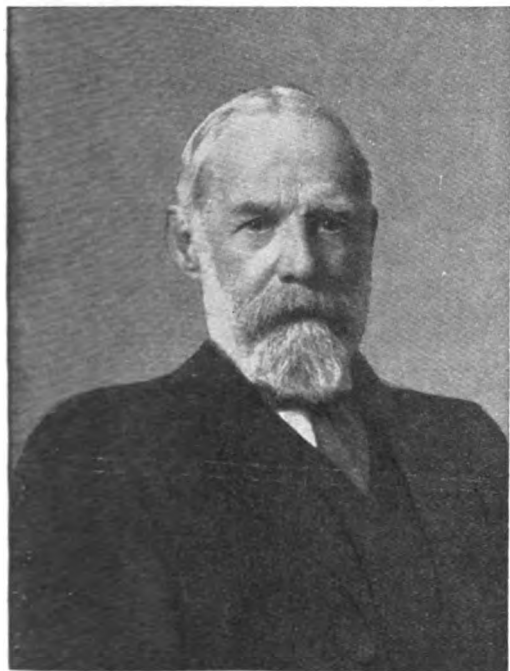
The Copernican theory involved far too profound a revolution in man's estimate of his own place in the universe to win early or easy acceptance. Even so great an astronomer as Tycho Brahe rejected it utterly. Yet its audacity and simplicity attracted the attention of every astronomer; the public mind became gradually familiarised with it; and the magnificent work of Kepler, in purging the system of Copernicus from its remaining errors, and in revealing the true laws of the motions of the planets, set the question finally at rest.

SIR GEORGE HOWARD DARWIN
Who Revealed the Earth's Motion by Calculations

Sir George Darwin was born at Down, in Kent, on July 9, 1845, the second son of the illustrious Charles Darwin and Emma, granddaughter of Josiah Wedgewood. He was placed at school at Clapham under the Rev. Charles Pritchard, who afterwards became professor of astronomy at Oxford. He proceeded, in 1864, to Trinity College, Cambridge, where he graduated, in 1868, as Second Wrangler, and in the same year was elected to a fellowship at Trinity College. He was called to the Bar in 1874, but, not having the physical health necessary for that life, soon returned to Cambridge, and threw himself into the profoundest mathematical problems of astronomy. He had already published a statistical inquiry into the effects of the marriages of first cousins, but his numerous scientific papers now dealt chiefly with problems of the mutual effects of celestial bodies revolving round one another; with the evolution of our solar system; and specially with the history of the relation between the earth and the moon. He was not an astronomical observer; his work consisted of abstruse calculations in his study at Newnham Grange, his home at Cambridge. In 1883 he was elected to the Plumian Chair of Astronomy and Experimental Philosophy, and was re-elected, in 1884, a fellow of Trinity.

His name is principally associated with the mathematical investigation of tides, their laws, and their effects. The problem of tides had already attracted the attention of Newton and Laplace, and Lord Kelvin had devoted much work to the subject before Darwin took it up and elaborated it to a point far beyond any which his predecessors had reached. Throughout all his

work on tides he was closely associated with Kelvin, to whom he dedicated the collected edition of his scientific papers.

This tidal study developed in two directions. It had its practical value, as affording further insight into the nature of the tides in the open ocean and along the coasts and in channels, and as facilitating the prediction of tides; and on this department ol his work Darwin communicated severaf papers to the British Association, in 1883 and successive years. On the other hand, it had its astronomical value, as affording insight into a factor which Darwin has taught us to regard as of great importance in cosmic evolution. It had been recognised since the days of Kant, who was the first to draw attention to the matter, that tidal friction must act as a brake, retarding the rotation of the earth and thus lengthening the day. But it was evident also, since action and reaction are equal, that the loss of energy occasioned by tides must be borne in part

SIR GEORGE DARWIN

by the tide-raising body—in our case, the moon—and that its orbit must be in course of time affected. Airy had worked a good deal at this problem with little result, but Darwin was able to show, by graphical methods of his own devising, that the moon is, up to a certain point, gradually driven away from the earth by these tidal effects; and was able to estimate that fifty-seven million years ago the moon and the earth formed one body, rotating in five and a half hours. He published, in 1901, an admirable popular work on tides and their effects in the solar system.

Darwin served for many years on the Meteorological Council, and later on the Government's Meteorological Committee, and was much consulted by the India Office on problems connected with surveys in the north of India, where the gravitative effect of the Himalayas introduces difficulties.

His "Collected Scientific Papers" were published by the Cambridge University Press in 1907 to 1911. He died at Cambridge on December 7, 1912.

WILLIAM RUTTER DAWES
A Discoverer of Double Stars

This great discoverer of double stars was born on March 19, 1799, at Christ's Hospital, London, where his father taught mathematics. The father was appointed Governor of Sierra Leone, and the boy was sent, in 1807, to live with Thomas Scott, author of a famous commentary on the Bible. Dawes was intended for the Church, but preferred to study medicine, and even practised for a time. But the parson was in him, after all; and when he began to observe the stars he was minister of a small Nonconformist chapel at Ormskirk, in Lancashire. Here he had set up for himself a small observatory with a good, though not a large, telescope. In 1839 he went to take charge of the private observatory at South Villa, Regent's Park; and in 1844 he moved again, to Camden Lodge, near Cranbrook. After a period of ill-health he began observing again at Wateringbury, near Maidstone, and removed once more to Hopefield, Haddenham, where he died, on February 15, 1868.

Dawes was an enthusiastic and very methodical observer. But his peculiar success can hardly be understood unless we credit him with extraordinary powers of vision. He distinguished a great number of stars, previously supposed to be single, as double stars, and discovered many comets. From the first he used to send his results to Sir William Herschel. He was the first Englishman to see, on November 25, 1850, Saturn's inner dusky ring, that was also discovered independently by Bond in America. He was a great student of Mars, and his drawings show "canals" before these were ever spoken of. The wedge photometer, for proving magnitudes of stars was his.

MR. CHARLES DAWSON AND DR. SMITH WOODWARD SEARCHING FOR FURTHER REMAINS ON THE SITE OF THE DISCOVERY OF THE SUSSEX MAN. Mr. Dawson is standing and Dr. Woodward sitting

GEOLOGISTS

THOMAS GEORGE BONNEY

A Microscopic Examiner of Rocks

PROFESSOR BONNEY, one of the greatest living British geologists, was born at Rugeley, in Staffordshire, on July 27, 1833. His father was master of the grammar school there, and vicar of a small parish five miles away. The boy was an ardent, self-taught student of natural science and a keen collector of fossils. Educated at Uppingham and at St. John's College, Cambridge, where he graduated brilliantly, both in the mathematical and classical Tripos, Mr. Bonney went abroad for his health in 1856, and spent some time in Switzerland. A second journey to the Alps in 1858 fixed his love for this region, and ever since he has visited it frequently, and has published several books on it of high scientific value and much general interest. Mathematical master at Westminster School from 1856 to 1861, he took Orders in 1858, and in 1861 returned to his college as Junior Dean. At Cambridge he did much to advance the study of natural science, and to increase the honour in which that department of learning was held.

Mr. Bonney soon became recognised as an authority on geology, and in 1869 he was appointed lecturer in that science. His devotion as a tutor is remembered by all his old pupils. Especially he impressed upon them the only real way of learning, by hard work at first-hand with the materials of their study; and after the labours of the term he would take groups of them away to study the rocks in remote parts of the British Isles. Elected Professor of Geology in University College, London, in 1877, and secretary to the British Association in 1881, Mr. Bonney worked for his London pupils as he had done for those at Cambridge, but under great difficulties for lack of equipment. He became President of the British Association in 1910.

Professor Bonney's geological work has been of wide scope and varied character. He was one of the pioneers in the microscopical examination of rocks, which has proved itself a most fruitful method. As a student, especially in Switzerland, of glacial action, he has resisted what he considers the extravagant estimate of the influence of ice in the formation of lakes and other surface features. He has devoted special study to the much debated question of the origin of coral islands and reefs, and was chairman of the Coral Reefs Committee appointed by the Royal Society. His investigations of the diamond have shown the origin of that stone in a rare igneous rock known as eclogite. His "Outline of the Petrology and Physical History of the Alps," read before the Geologists' Association in 1897, is an example of masterly generalisation.

Besides an intimate knowledge of the Alps, in which he has few rivals, Professor Bonney has gained acquaintance, in his geological travels, with the Pyrenees, and many parts of France, Italy, Scandinavia, Denmark, Germany, and Canada. Having resigned his professorship in 1901, he returned, in 1905, to Cambridge, there to continue literary and scientific work.

LEOPOLD VON BUCH

A Champion of Fire Against Water

Leopold von Buch, one of the greatest of German geologists, was born at Stolpe, in Pomerania, on April 26, 1774, of a noble and wealthy family. His inborn passion for the study of Nature was shown from his earliest years. Proceeding at the age of sixteen to the Mining Academy of Freiberg, he lived there in the house of Professor Werner, a famous mineralogist and teacher,

and formed a lifelong friendship with the illustrious Humboldt, who was a fellow-student. During this time, and his succeeding courses of study at Halle and Göttingen, Von Buch investigated the neighbouring regions, and, after holding for a few months a Government appointment, regained his liberty in 1797 to give his life to geological travels.

Among the regions through which he wandered, studying the rocks, were Silesia, in 1796; the Alps, Italy, and especially the neighbourhood of Rome and of Naples, in 1798; the Canton of Neuchâtel and the Alps and Jura Mountains, from 1799; Auvergne, in 1802; Naples, in 1805, where, with Gay-Lussac and Humboldt, he saw Vesuvius in eruption; the following year, until 1808, in Norway and Lapland; then for some years in the Alps again; to the Canary Islands, in 1815; Scotland, for the West Highlands, and especially Staffa and Fingal's Cave, in 1817; then almost every year to the Alps, though occasionally to other parts of Europe. He lived in Berlin, where he was socially of the highest rank, and had great influence; and there, on March 4, 1853, he died. Professor von Zittel, describing Von Buch's travels, says: "Most of his Alpine journeys were accomplished on foot. Clad in short breeches, black stockings, and buckled shoes, the pockets of his black coat stuffed with notebooks, maps, and geological tools, his tall, imposing figure was bound to attract attention. His travelling luggage was limited to a fresh shirt and a pair of silk stockings. His physical endurance was only surpassed by his iron determination, which could overcome all difficulties and discomforts. Socially, he was everywhere beloved; his aristocratic bearing, his mastery of foreign languages, his wide knowledge of science and literature, all combined to make him one of the most agreeable companions."

Von Buch was a geologist with a universal interest in his favourite science, but his greatest contribution to it was the demonstration of the part which igneous and volcanic action had played in the formation of the rocks. Werner, his friend and teacher, had unduly extended the importance of aqueous action, regarding basalt, for instance, as a sedimentary deposit, and explaining volcanic activity as due to the combustion of deep-seated coal. Again, Werner regarded mineral veins in rocks as due to the descent, from the surface of the earth, of water loaded with minerals in solution. This Neptunian theory had a great vogue in Germany, but was disproved, or, rather, restricted to its right place, by the labours of Humboldt in Central and South America, and of Von Buch in Europe and the Canary Isles. But Von Buch's many papers and books dealt also with the most varied geological questions. His geological map of Germany, involving enormous labour, is a classical work. "Through Norway and Lapland," besides descriptions of the rock strata, includes studies of the climate of those regions; of the raised beaches of Scandinavia, which he regarded as due to a rising of the coast, and not to a falling of the sea-level; and of the Scandinavian rocks from which the ice had brought boulders to the German plains. "A Physical Description of the Canary Islands" is a profound study of volcanic action that has there been at work on a vast scale. Many of his later papers are devoted to the fossil forms of ancient molluscs.

Leopold von Buch wrote of the scenes he interpreted in a peculiarly vivid and picturesque way. He was a great mineralogist, but was far more than a dry-as-dust breaker and classifier of stones. He was artist as well as scientist, and scenery and geology were for him a living unity, so that landscape became significant of the structure of the rocks. This power of vision is reflected in his literary vigour.

THOMAS CROWDER CHAMBERLIN

An American Student of Glaciers

One of the most accomplished American geologists, Professor Chamberlin, was born near Mattoon, Illinois, on September 25, 1843. He graduated at Beloit College in 1869, and after four years as a teacher in the normal school at Whitewater, Wisconsin, was appointed to the Chair of Geology at Beloit, which he held from 1873 to 1882. From 1885 he was for two years Professor of Geology at the Columbian University, Washington, and was then appointed president of the University of Wisconsin. Since 1892 he has been Professor of Geology in the University of Chicago, and since 1902 has been connected with the Carnegie Institute as investigator of geological problems. He accompanied, as geologist, the Peary Relief Expedition of 1894.

America has learned much from Europe in the way of science, but the indebtedness is by no means only on one side; and the Old World owes the modern science of physiography to the labours of the New. "It was in the wide plateaux of America,"

says Professor von Zittel, historian of geology, "that the first signal successes of physiographical geology were won. . . . By their vivid portrayal of the work of subaerial denudation the American writings roused the intellectual life of the middle of the century to new conceptions on a grand scale. The gigantic erosion-forms in the Bad Lands, the configuration of the Rocky Mountains and of the plateaux lands in Arizona, Colorado, and Mexico, the wonders of the Yellowstone Park and California, called forth a new and rich literature, which demonstrated in the most convincing way that the surface-forms of those regions are mainly the result of the erosive activity of water." In the eastern and middle States, however, the agency of ice is predominant, and Professor Chamberlin's most important work has been in connection with glacial action. He made, in 1878, a study of the Swiss glaciers, having been sent to Paris to represent the Legislature of Wisconsin at the International Congress of Geologists. He was shortly afterwards placed in charge of the glacial section of the United States Geological Survey, a position which he has now occupied since 1882. Among his more important works may be mentioned "Our Glacial Drift," "Geology of Wisconsin," and, in collaboration with Professor Salisbury, "Geologic Processes."

JAMES CROLL
The Wheelwright Who Set the World Arguing

A self-taught geologist of humble origin, who is remembered chiefly for certain bold speculations with regard to the causes of climatic change, James Croll was born at Little Whitefield, in Perthshire, on January 2, 1821. His father was a stonemason, and James, after attending the village school, was apprenticed to a wheelwright. He worked for some years as a joiner, but his health was too delicate, and he had to seek a lighter occupation. In 1847 he opened a small shop in Elgin, but illness interfered, and he left the town in 1850. Having married, he set up a temperance hotel at Blairgowrie, with no greater success. But fortune changed when Croll was appointed keeper of the Andersonian Museum in Glasgow. It was work which really suited him, for he was a keen student, and had already written several papers, chiefly on subjects connected with climate and physical laws. He had leisure for his studies and the opportunity of consulting books and of conversation with men of knowledge, and was, moreover, regarded as an excellent curator. Promotion followed when, in 1867, he was put in charge of the maps and the secretarial work of the Geological Survey of Scotland. His first book, "Climate and Time," which is also by far his best, was published in 1875. In 1880 he retired from his position on the Geological Survey on a pension of little more than a pound a week, and devoted himself entirely to study and writing. The results were "Climate and Cosmology," in 1885, a reply to the keenly adverse criticism which his earlier work had called out; "Stellar Evolution," in 1889; and "The Philosophical Basis of Evolution," in 1890. He died on December 15, 1890. Croll found the cause of climatic variations, such as those of the glacial epoch, in modifications of the earth's orbital relation to the sun. The theory was ingenious and elaborately developed, but scientific opinion has not tended to confirm it.

JAMES DWIGHT DANA
The Iron Heart of the World

James Dwight Dana was born at Utica, in the State of New York, on February 12, 1813, and was educated at Yale, where he studied especially mathematics, physics, and chemistry. He visited Europe during his university career. In 1836 he became assistant to Professor Silliman, at Yale, and in 1838 was chosen to accompany the Wilkes Exploring Expedition as geologist and mineralogist. In the course of the voyage along the South American coasts and among the islands of the Pacific, Dana collected a vast amount of material for zoological and geological research. He was wrecked on the coast of Oregon, but sailed again from San Francisco, by way of Singapore and St. Helena, to New York, thus circumnavigating the globe. The spoils of these four ocean-years took more than three times as long to study and describe in his celebrated works, "Report on Zoophytes," 1846; "Report on the Geology of the Pacific," 1849; and his "Report on Crustacea," published in 1854.

In 1850 Dana was appointed Professor of Geology at Yale, and served till within three years of his death, on April 14, 1895. His was the predominant influence in forming the brilliant American geologists and physiographers who have succeeded him; or perhaps we should rather say that his influence was second only to that of their marvellous continent itself. He was a man of large mind, vast knowledge gained at

first-hand in the study of Nature, and bold conceptions. His belief, for which there is much to be said, that the earth is elongating in the direction of the Poles and contracting in its equatorial diameter, is, whether true or not, an example of a simple conception which unites many diverse phenomena. A similar example is his theory of the constitution of our globe—that two-thirds of its mass consists of iron, forming a rigid core or nucleus, surrounded by a hot, viscous envelope of molten rock-stuff, the whole being enclosed by a solid, hard crust about seven miles thick. Volcanoes and volcanic action always interested him deeply; he was the first, in 1840, to give a scientific account of the strange, silent volcanoes of the island of Hawaii, with their giant cones; and one of his last and most important works was the "Characteristics of Volcanoes, with Contributions of Facts and Principles from the Hawaiian Islands," published in 1890. Coral reefs were also a subject of his study; he was a strenuous supporter of Darwin's theory that reefs and atolls are formed during the gradual subsidence of the sea bottom—a view which has been as vigorously contested by many, and perhaps most powerfully by Sir John Murray. Whichever hypothesis turns out to be true, or whether, as is probable, various coral reefs are formed in various ways, Dana's "Corals and Coral Islands," issued in 1879, will always remain a classic.

But Dana's greatest contribution to geological science is unquestionably his explanation of the origin of mountains by the crumpling of the earth's crust caused by lateral compression. The theory was outlined by his papers, as early as 1846, in the "American Journal of Science." It is the chief example of his extraordinary power of bold and simple conception, associated with close investigation of all the related facts of every kind. The hypothesis, or rather the now established scientific principle, was suggested to him by an intimate study of the Appalachian Mountains, which are excellent models of rock-strata crumpled and thrown up by the enormous horizontal compression consequent upon the shrinking of the earth's interior. In the study of this subject Dana was helped greatly by the collaboration of Le Conte, and other American geologists contributed studies from the Rocky Mountains and elsewhere in support of it, but the credit of discovering the chief cause of mountain structure undoubtedly belongs to Dana.

The career of this wonderful scientific worker is only one of several demonstrations of a principle which should be more impressed than it is upon young students. The lecture-room, museum, library, laboratory are all very well in their way, but they are never the real thing. The best they can give is second-hand, artificial knowledge. The lives of Humboldt, Dana, Darwin, Bates, Wallace, Murray, and many others all teach that the way to understand the face of the world is to go out and see it.

WILLIAM BOYD DAWKINS
Searcher of the Earth for Signs of Man

Professor Boyd Dawkins was born at Buttington Vicarage, Welshpool, Montgomeryshire, on December 26, 1838. He was educated at Rossall and at Jesus College, Oxford, where he graduated in classics and in natural science, and was the first Burdett-Coutts geological scholar at Oxford. He was appointed in 1861 to the Geological Survey as assistant, and became, in 1867, chief geologist. In 1872 he became Professor of Geology in Owens College, Manchester, and later honorary Professor of Geology and Palæontology in Victoria University, Manchester, which position he still occupies. Professor Boyd Dawkins is widely known as an authority on anthropology, as well as on geology and palæontology, and popularly is most prominently associated with the fascinating study of caves and underground watercourses. He is the author of many papers on fossil remains, especially those of mammalia, and on evidences relating to the antiquity of man. His earlier travels were throughout Europe, to collect the material published, in 1874, under the title of "Cave-Hunting: Researches on the Evidences of Caves Respecting the Early Inhabitants of Europe." In 1874 he undertook a voyage round the world. "Early Man in Britain, and His Place in the Tertiary Period," was published in 1880. Others of his writings deal with various aspects of the geology of the Isle of Man.

Professor Boyd Dawkins has given much study to the English coal measures, and the discovery of the coalfield in the south-east was due to his researches. His geological knowledge has been called upon to assist in several great engineering works, such as the tunnel under the Humber.

Elected, in 1882, president of the Anthropological Section of the British Association, he presided, in 1888, over the Geological Section. He gave the Lowell lectures in 1880, and was awarded the Lyell medal in 1899.

CHARLES DAWSON

Discoverer of the First Known Man

Mr. Charles Dawson, the palæontologist, is a solicitor practising at Lewes, Sussex. Outside his own town his name is probably unknown to the man in the street. Yet his fame will go down to posterity as having opened to his generation one of the most startling and fascinating chapters on the ancestry of man that has yet been inscribed by human hands upon the book of life. Mr. Dawson has been a geologist and archæologist from early boyhood. Instead of moths and butterflies he followed in the track of extinct monsters, tracks imprinted in the rocks of his native Sussex when those rocks were still mud in a marshy twilight world. He traced the way that the megalosaurus had gone, and discovered three new species of iguanodons, one of which is named after him. He brought to light fossil plants of an uncommon kind, fossil fish dear to students of the story of ichthyological evolution, and many interesting mammalian remains.

Most of these he himself unearthed, or purchased of the wondering quarrymen of Hastings and elsewhere, who pocketed his gratuities, and reserved their opinion as to his sanity and sense of values in such old gear. Little by little his private collection grew until he was no longer able to house it. Then grave and learned men foregathered at his house, scrutinised his specimens, and catalogued and packed and despatched them. And lo, a new and important group, named the Dawson Collection, was added to the priceless treasures of the Natural History Museum at South Kensington.

The collection has continued to grow, fed by its finder's continued gleanings from the rocks and soils of ancient Sussex, whose bosom is a charnel-house of history, written in fossil and in bone. In the course of his explorations, Mr. Dawson announced the presence of natural gas in Sussex, and to this day the station and hotel at Heathfield are lighted by the product of his discovery. Water, too, he located by the scientific method of the geologist.

His crowning achievement was not announced until 1912. While walking on the common at Piltdown, Sussex, in the early winter of 1911, he observed workmen digging gravel for farm roads. One of them handed him a fragment of a human skull, which they had broken in their digging and thrown away. Had he been an hour later or an hour sooner, he would have missed the great secret. He realised that he had here a pearl of price, or rather a portion of a pearl, for the major portion of the skull was still to seek. Many times he revisited the spot in the hope of gathering further clues, and at last retrieved two other fragments. With these and the original he went to the Natural History Museum, where he was encouraged by Dr. Arthur Smith Woodward, Keeper of the Geological Department, to pursue his investigations. But the floods of winter filled the cavity whence the precious relics had been won, and not until the end of May was he able to continue his work.

A further search of four months was rewarded by the discovery of the remainder of the skull, and half the lower jaw. Associated with these remains were fragmentary relics of two very primitive elephants, a hippopotamus, the common red deer, a horse, and a beaver. An examination of the surroundings revealed evidence of the great antiquity of the site. Since the deposition of the formation in which he was working, the river Ouse had changed its course, and cut itself a channel 80 ft. deeper than the level at which it ran when it built up this precious matrix of past life.

The skull proved to be the most important ever discovered. It takes us far back beyond the rise of the cave-man, hitherto the earliest known type. It seems, so far as investigations have gone, that the skull was that of a woman typical of a race from whom the cave-men sprang; that the cave-men died out, and that, contrary to all earlier theories, the present type of human beings descended, not from these, but from the primitive source of which the Piltdown skull affords the first evidence. The cave-man developed the low forehead and protuberant brows of the adult ape; the Piltdown skull reveals a type in which the skull closely resembled that of the very young chimpanzee, which lacks the massive bony prominences over the brows which it later assumes. Therefore, the changes that took place in the skull in successive races of early men were, it is held, exactly similar to the changes which now occur in the skull of an ape as it grows from youth to maturity.

The high importance of the find has gained world-wide recognition, and casts of the skull are being distributed broadcast among museums and learned societies. Dr. Woodward asserts that the discovery takes us nearer to the source and origin of the first human creature than any

discovery ever made before. He regards the Piltdown skull as the long-sought missing link, or at least a missing link, for there may be another, perhaps others, he says. But here, at all events, we have a species almost entirely ape.

He adds this interesting statement: "The most significant thing about this discovery does not so much lie in the fact that the brain is infinitely smaller than that of an ordinary human being, or that the jaw is the jaw of a chimpanzee, but in the fact, proved beyond doubt from the shape of the jaw, that the creature, when alive, had not the power of speech. Therefore, in the evolution of the human species, the brain came first, and speech was a growth of a later age."

While these pages are passing through the press, Professor Elliott Smith, the eminent anthropologist, is about to discuss the whole question of this ancient creature that knew no vocal method of communication. Meanwhile, Mr. Charles Dawson, the quiet, unostentatious surveyor of rocks and fields and downs, of whom none but the learned few have heard, has placed the entire thinking world in his debt for the perseverance and assiduity with which, proceeding from find to find, and from knowledge to knowledge, he has revealed to us our earliest known ancestor.

SIR JOHN WILLIAM DAWSON
A Canadian Opponent of Darwin

The most distinguished of Canadian geologists was born at Pictou, Nova Scotia, on October 30, 1820. He was educated at Pictou College and Edinburgh University, where he graduated in 1842. In the same year he joined Sir Charles Lyell in a geological study of Nova Scotia, returning in 1846 to Edinburgh to study chemistry. He worked again with Lyell, in 1852, in an investigation of the carboniferous vegetation —Dawson's chief field of research—when they brought to light reptilian remains of great interest.

Appointed, in 1850, Superintendent of Education in Nova Scotia, and in 1855 Principal and Professor of Natural History in McGill University, Montreal, Dawson effected, by his zeal and public spirit, a great advance in the standard of Canadian education. For many years he lectured on natural science at the McGill Normal School. He founded the Royal Society of Canada, and was its first president. He presided over the British Association on the occasion of its visit to Birmingham in 1886.

It is unfortunate that the name of Dawson, who carried out very brilliant geological work, should be generally associated with an error. MacCulloch had found, in 1858, in the Canadian Laurentian gneiss, very remarkable combinations of serpentine and calcite, in which the serpentine was ramified through the calcite in a curiously reticulated way, strongly suggestive of a foraminiferous growth. Dawson described it as such, in 1864, under the name of Eozoon Canadense; and the supposed discovery attracted great attention, because Eozoon was obviously, from the nature of the rocks in which it was found, the earliest of all organic fossil remains. Many high authorities supported Dawson's view, but Moebius of Kiel finally proved that the structure was of inorganic origin.

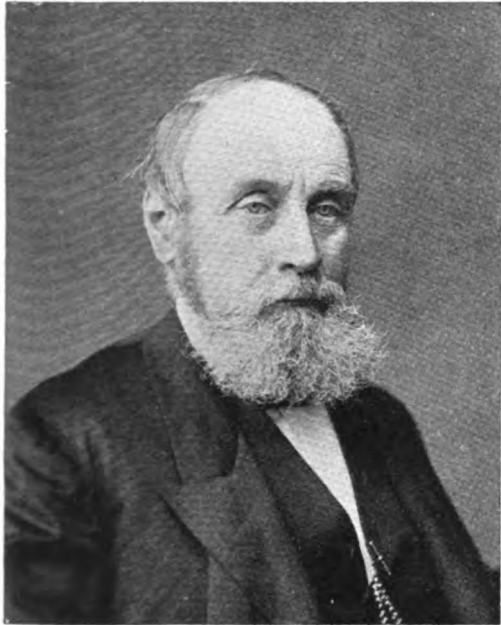
Dawson was an able controversialist and a keen opponent of the Darwinian theory. Besides many scientific papers, he wrote several more popular works, including "The Dawn of Life," 1875; "The Origin of the World," 1877; and "The Meeting-Place of Geology and History," 1894. He was knighted in 1884. He died in Montreal on November 20, 1899.

HORACE DE SAUSSURE
The First Scientist to Climb Mont Blanc

Horace Bénédict de Saussure was born in Geneva on February 17, 1740, the son of wealthy and noble parents. Scientific interest was hereditary in the family, and De Saussure's father was a well-known writer on agricultural subjects. The boy was an eager collector of rocks and plants, and a walking tour at the age of twenty fired him with a love of the Alps which became a lifelong passion. De Saussure, who had been highly educated, was appointed, in 1762, Professor of Philosophy at Geneva, but natural science was his chief interest.

It is to De Saussure that the modern world owes the great sport of mountain-climbing. He carried out, in 1787, his ascent of Mont Blanc, and in subsequent years conquered the peaks of Monte Rosa, the Breithorn, and others. Like many who have followed him, he thought that the grandeur of the view from these summits repaid every fatigue and danger, and felt that to climb a mountain was in some sense to come near to truth. The botany of the Alpine flora, which was his first study and his last, was the subject of his earlier papers; and from thence he proceeded to a thorough study of the mineralogy and geology of those mountains. De Saussure was the first

to study in the laboratory the fusion of rocks, and may thus be regarded as the originator of experimental geology.

His classical work, entitled "Voyages dans les Alpes," is a monumental record of his geological journeys, researches, and experiments. The first volume appeared in 1779, the second in 1786, and the last two in 1796. During the long period of their composition he continued to travel over not only the Alps, but also the Vosges, the mountains of Germany, Italy, Sicily, and the ancient volcanoes of France. He delighted in mountains, and his descriptions of them, always accurate, are also charming. De Saussure, fortunately, held no brief

SIR JOHN WILLIAM DAWSON
Photograph by C. G. Mason

for any special theory; he was content to observe closely, and to tell what he had seen. He rightly held that geological knowledge could not be greatly advanced by a study of the plains, and that only the mountains could reveal the secrets of terrestrial history.

De Saussure wrote also an admirable little work, entitled "Instructions to Young Geologists," warning them against the tyranny of abstract theories, and counselling patient and detailed observation.

Professor von Zittel remarks that "De Saussure's love of truth and his passion for Nature, combined with the extreme modesty of his attitude towards the science of the mountains, have made him an ideal personality in the annals of Alpine geology. Endless in his energy, insatiable in his desire to accomplish, De Saussure, at the conclusion of his life's labours, writes that he has found nothing constant in the Alps except their infinite variety. With a feeling of sadness he admits the futility of all his efforts to wrest the eternal truths of Nature from the majestic peaks of his native land."

De Saussure died on January 22, 1799.

NICHOLAS DESMAREST
The Man Who Walked to Fame

Nicholas Desmarest was born at Soulaines, near Brienne, in France, on September 16, 1725. His father was so poor that, when he died, Nicholas, who was then fifteen years of age, had received no education. He was afterwards taught gratuitously by the Oratorians at Troyes and at Paris. For ten years after leaving them he earned a scanty livelihood by teaching. His opportunity came when a scientific society offered a prize for an essay dealing with the question whether France and England were ever joined together. The question attracted Desmarest. He won the prize, and with it the friendship of D'Alembert and the favour of men in high place. He received employment in the investigation of industrial conditions, and in 1788 was made inspector-general and director of the manufactures of France. His labours in this capacity were very beneficial to industrial development.

Throughout his life Desmarest made continual expeditions, always on foot, over the greater part of France. A shepherd's hut for shelter, bread and cheese for wayside fare, devious tracks for his road, and the company of the humblest of the people as he went along—thus Desmarest learned to know the features of his native land as no one had known them before him. Wandering thus, in 1763, he came upon the region of the old volcanoes of Auvergne, and pondered upon the nature of the basalt there. Two years later he laid before the Academy of Sciences his conclusion that basalt was of igneous origin—was, in fact, lava. But, wishing to make sure of his discovery, he would not allow the paper to be published until 1774, after he had twice again visited the extinct volcanoes of France, and had also travelled in volcanic districts of Italy.

He became so certain of his conclusions that he would not even discuss the controversy which arose between those who regarded basalt as an aqueous deposit and those who believed it to be igneous, but

would only say, when questioned, "Go and see." In 1775 he presented to the Academy of Sciences a monograph "On the determination of three epochs of Nature from the products of volcanoes, and on the use which may be made of these epochs in the study of volcanoes," and this work was published in 1806. The correctness of his conclusions with regard to the stages in the history of volcanoes has been confirmed by later study.

The later years of his life were occupied in the compilation of his "Physical Geography," of which four volumes appeared between 1794 and 1811, and the fifth was unfinished at his death; and also in constructing his invaluable geological map of the Auvergne district.

Desmarest died on September 20, 1815, having continued his pedestrian travels almost until his death. His nature was one of absolute sincerity, simplicity, and humility.

SIR ARCHIBALD GEIKIE
The Foremost British Geologist of Today

Sir Archibald Geikie, the most authoritative British geologist of today, was born in Edinburgh on December 28, 1835, and was educated at the Royal High School and at Edinburgh University. He was always a lover of Nature, with a keen sense of landscape, and became a geologist on the day when he discovered, with a party of school friends, a wealth of fossil remains in an old quarry. At the age of twenty he joined the Scottish Geological Survey, and became its first director in 1867, when it became an independent institution. He did an immense amount of most valuable work on the Survey, elucidating many stratigraphical problems in the Highlands.

A new Chair of Geology and Mineralogy was founded at Edinburgh University in 1871, and Sir Archibald Geikie held it until 1882, when he was appointed Director-General of the Geological Survey of the United Kingdom, and Director of the Museum of Practical Geology in London. His knighthood dates from 1891. He has, of course, received all kinds of honourable recognition from all parts of the world.

His geological travels extended over the greater part of Europe and vast tracts of North America. His geological work has been very various. Thus, his essay on "Modern Denudation," in 1868, was the first to give careful calculations of the amount of land material which rivers annually transport to the sea, and showed how a hilly surface might be levelled to an absolute plain by the work of frost and rain and stream. He believes that even submarine plains or platforms owe their level surface to the same process, before these regions were submerged under the ocean.

Volcanoes and volcanic action have been the subject of Geikie's most important work. As early as 1861 he began a series of investigations in Scotland, which extended over thirty-five years, and made the Western Isles of the Highlands the most famous ground for the study of ancient volcanoes.

Like his brother James, Sir Archibald Geikie has been an ardent supporter and exponent of the theory by which many geological phenomena are referred to the action of ice, in a succession of glacial epochs alternating with periods of warmer climate, and adheres in general to the views propounded by James Croll, in his book on "Climate and Time."

Sir Archibald Geikie has dealt with every geological question arising from the Scottish strata, and his name is especially associated with the Old Red Sandstone.

His "Textbook of Geology," which has passed through several editions, is the best extant manual of the science.

JAMES GEIKIE
A Student of Climate in the Days Before Man

James Geikie, Professor of Geology and Mineralogy and Dean of the Faculty of Science, Edinburgh University, was born in Edinburgh, in 1839, and was educated at the High School and University of Edinburgh. In 1861 he entered H.M. Geological Survey, and held this post till 1882, when he was appointed to the Murchison Chair of Geology, in succession to his brother, Sir Archibald Geikie. While engaged on the Geological Survey he mapped the larger portion of the Clyde coalfield, as well as considerable tracts of Ayrshire, Renfrewshire, Berwickshire, Roxburghshire, Perthshire, and Forfarshire. During the course of these researches he devoted special attention to the superficial formations which cover so large a part of the surface of Scotland. He was the first to point out (1866) that the Scottish peat-bogs furnished evidence of cold and wet conditions of climate having alternated with epochs of more genial conditions during which great forests flourished. Within the past few years these views have been amply confirmed by the botanical researches of Dr. Lewis.

Mr. Geikie's examination of the glacial accumulations of Britain led him to conclude

that these indicated great oscillations of climate—that the Pleistocene period consisted of a cycle of alternating cold or glacial and warm interglacial epochs, and that the peat-bogs, with their buried forests, represented the closing phases of the great cycle. He further pointed out that palæolithic man and the extinct or no longer indigenous mammals associated with him lived in Britain during interglacial times, and were not of post-glacial age, as had hitherto been supposed. These views were elaborated in his work "The Great Ice Age, and its Relation to the Antiquity of Man.'

The same theme is discussed in his "Prehistoric Europe" (1881), with special reference to "that succession of changes, climatic and geographical, which, taken together, constitute the historical geology of Pleistocene, post-glacial, and recent times." Another branch of his science in which he has done much work is that which deals with the origin of the surface features of the land. This subject he has discussed in numerous essays communicated to scientific journals, and more fully in his "Earth Sculpture, or the Origin of Land Forms" (first edition, 1898; last, 1909). He has also in the press a work entitled "Mountains, Their Origin, Growth, and Decay."

SIR ARCHIBALD GEIKIE
Photograph by Lombardi

PROFESSOR JAMES GEIKIE
Photograph by Elliott & Fry

For many years Professor Geikie has been a strong advocate of the importance of geography as a subject of instruction, not only in schools but in universities. He is one of the founders of the Royal Scottish Geographical Society, of which he was president for a number of years. He has also acted for many years as honorary editor of the "Scottish Geographical Magazine," which is the organ of that society. His studies have ranged over a wide field, and have not been confined solely to scientific investigations. He has always been a keen student of foreign literature, and in 1887 published "Songs and Lyrics by Heinrich Heine, and other German Poets."

Besides the original scientific works mentioned above, Professor Geikie has published a number of valuable textbooks on various phases of geology

JEAN ÉTIENNE GUETTARD

The Inventor of Geological Maps

Jean Étienne Guettard was born at Étampes, near Paris, in 1715. He was intended to follow his grandfather's profession of apothecary, but his love of natural history led him to study medicine. The Duke of Orleans, who was a distinguished amateur of the sciences, engaged Guettard to accompany him on his travels, and to act as curator of his collections of animals and plants. Botany was Guettard's first interest, but he was led on to geology by observations of the relation between the distribution of plants and the minerals

and soil of various districts. Guettard was an extremely versatile man of distinctively French genius. From the study of fossils, which he was the first to connect biologically with their modern representatives, he was able to demonstrate the fact that the European continent had in former ages lain under the sea; and this view, though familiar enough today, was in his time fiercely contested.

Guettard performed three signal services to geology, which stand out far above much miscellaneous work. He invented geological maps; he discovered the ancient French volcanoes of Auvergne; and he laid down the principle that mountainous lands are ultimately degraded to the level of plains by the action of rain and stream. He drew uncoloured geological maps of France and England, the former chiefly from observation, but the latter, which is greatly inferior, only from second-hand book-knowledge. And he undertook a vast project to prepare a mineralogical atlas of the kingdom of France.

The preparation of this atlas, which was never completed—Guettard drew twenty-nine parts and Monnet thirty-one—had the effect of stimulating a new and widespread interest in mineralogy throughout France, and many monographs began to be published with regard to the geological detail of local areas. All this reacted in a very healthy way upon the science of geology, so that, though Guettard's maps are very inferior to those to which we are accustomed today, they are not by any means to be despised.

The discovery of the ancient volcanoes was due to Guettard's keen power of observation. He was travelling along the road to Moulins when he noticed that houses and walls were more and more built of black stones, and on examination found these to be of the nature of lava. By following along the roads where the black stones became more frequent, and turning back when they diminished in number, he was led ultimately, accompanied by his friend Malesherbes, to the extinct volcanoes, which had hitherto been unknown. His paper "On certain mountains of France which were formerly volcanoes" was presented in 1752 to the Academy of Sciences, and published in 1756. The discovery was of great importance in the development of geology, for it led to Desmarest's conclusion that the widely distributed mineral known as basalt is identical with volcanic lava.

Guettard's ingenuity as a palæontologist is well shown in his memoir "On the accidents which have befallen fossil shells compared with those which happen to shells now living in the sea." He died on January 7, 1786.

SIR JAMES HALL
An Explorer of Volcanoes

Sir James Hall was born at Dunglass, in Haddingtonshire, on January 17, 1761. He was educated in London and at Cambridge University, and then travelled on the Continent for three years, returning to Edinburgh in 1781. From this time he devoted himself altogether to geology, and especially to the study of volcanoes. In 1785 he went to Italy, ascended Vesuvius and Etna, and visited the Lipari Isles. Here he discovered the true nature of volcanic dykes, or vertical lavas, which he investigated on Monte Somma, a part of Vesuvius.

His reputation rests chiefly on his application of experimental methods to geological research. He was first led to these experiments by his interest in the work of Hutton, who was his intimate friend, but Hutton saw little use in laboratory work, and Hall did most of his work after Hutton's death, in 1797.

Sir James Hall's experiments rendered enormous service to geology, not only by their particular results, but even more by his establishment of practical work as a powerful method of research. Among his more important results are the proof of a close affinity between the modern lavas of Italy and the old basaltic formations of Scotland and Ireland, thus confirming the view of Desmarest that basalt is a volcanic product; the demonstration of the effect of compression in modifying the action of heat upon rocks; and the elucidation of the processes which take place in the folding of strata. Another important result of Hall's work was that a group of able experimental geologists arose in Edinburgh. Sir James Hall died on June 23, 1832.

He must not be confused with the American geologist James Hall, who was born on September 12, 1811, at Hingham, Mass., became director of the Natural History Museum in Albany, and died there in 1898. This American student of geology, a contemporary of Dana, did much valuable work in the study of the formation of mountains and in classifying the strata of North America. His work on the fossils of the State of New York, published in several large volumes under the title "Palæontology of New York," was the fruit of enormous industry and learning.

BIOLOGISTS

ROWLAND BIFFEN

The Scientific Transformer of Agriculture

Rowland Biffen, who was educated at Emmanuel College, Cambridge, is consulting botanist to the Royal Agricultural Society. When it was decided to reorganise agricultural studies in Cambridge, Mr. Biffen was appointed Professor of Agricultural Botany, and he has held this Chair since 1908. The date was a fortunate one, for by that time the essential facts of Mendelism had become established beyond dispute, thanks chiefly to Professor Biffen's colleague, Professor Bateson, and so it was possible to start the serious work of research upon sound and fruitful lines. What may be called the "nurture" side of agricultural botany has not been studied at Cambridge, that being dealt with at Rothamsted. Professor Biffen has directed himself to the nature or heredity side. There our exact knowledge of wheat in 1908 was nothing at all.

The first need was to study the genetics of wheat, so that the various Mendelian factors might be isolated, and then it had to be ascertained whether desirable factors could be combined to a novel extent, with the creation of new and valuable forms of wheat, or whether that "repulsion of factors" of which recent Mendelism has so many illustrations would make any useful new combinations impossible. Professor Biffen had no great difficulty with the inquiries into genetic fact, though the results of those inquiries were such as to lead to tempting offers from abroad for his services there instead of at Cambridge.

Then came the constructive stage of work. The object was to combine the good cropping power of the best English wheats with the "hardness" and the freedom from "rust" of the best foreign wheats. The hard foreign wheats rapidly deteriorate when grown here. But by Mendelian breeding Professor Biffen was able to conquer all these difficulties. He obtained a wheat which was "completely immune to the attacks of the rust fungus, though in other respects it had no desirable quality to recommend it." But, having found that immunity to rust, heavy cropping capacity, and "hardness" of the grain could all be determined as Mendelian factors, in a few years Professor Biffen was able "to build up a strain of wheat which combines the cropping capacity of the best English varieties with the hardness of the foreign kinds, and at the same time is completely immune to rust."

We already know that this wheat will retain its qualities for years. One variety of it, sown in 1910, produced from one quarter forty-three. All this was used for seed, and produced 770 quarters, which realised £1666 in the market. There are many good judges who predict that in a few years these products of the scientific research of Professor Biffen and his school will revolutionise our national agriculture.

HERMANN BOERHAAVE

A Doctor who Prescribed for All Europe

Hermann Boerhaave was born, near Leyden, on the last day of the year 1668. His father was a clergyman, and the boy early received and repaid a good education of the literary and academic kind. He went to the famous University of Leyden at the age of sixteen, and there, after some years of study and a period of penury, during which, owing to his father's death, he had to live by taking mathematical pupils, we find him installed as professor of what is now called physiology, at the age of thirty-three.

In those days botany played a large part in medical study, and Boerhaave did much for medical botany during the several years which elapsed before he had opportunities of showing his originality in medicine itself. As a great centre of liberal learning, Leyden already had a botanic garden, which Boerhaave greatly extended.

But this original and devoted student of living Nature is to be remembered not as a botanist, and certainly not as a student of the botanical part of the pharmacopœia. He was a pioneer student of disease in days when any real medical knowledge was so slight, compared with the mass of nonsense that was believed, as to be scarcely credible today. It was as a modern "father of medicine," worthy to be so named even with Hippocrates in our memory, that Boerhaave is to be honoured. He made his own small town famous throughout the world; and one of the most notable consequences of his work, and of the way in which he drew students from foreign countries, was the foundation of the school of medicine in Edinburgh, which has since that date nourished such men as Syme and Simpson and Lister.

Boerhaave made many observations in botany and chemistry, the latter bringing him such honours as election to the French Academy of Sciences and our own Royal Society. But he was most famous and original as what we nowadays call a "clinical observer." He had been a close student of the writings of the English physician Sydenham, and from him had learnt the value of genuine, first-hand, critical observation of his patients. This led him, for instance, to institute at Leyden the system of teaching students at the bedside, which is now called clinical teaching, and is the central feature of every soundly conceived medical and surgical curriculum.

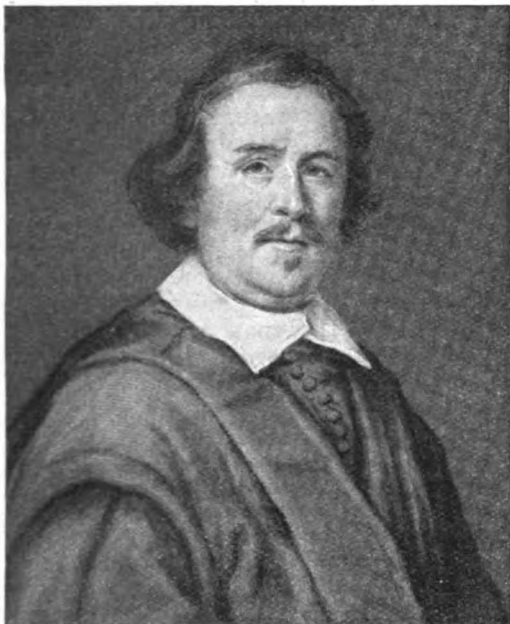
In the text-book of Boerhaave's lectures, published at Leyden in 1709, we find his conclusions upon the diagnosis and "differential diagnosis" of disease.

The moral qualities of Boerhaave, and the breadth of mind which reposed, or rather acted, upon them, are perhaps the real key to his greatness. Among his contemporaries, though forty-four years older, was the English clinician Thomas Sydenham. To him his Dutch junior yearly referred in his lectures as "The light of Anglia, the Phœbus of skill, the true likeness of the Hippocratic Man." Anyone who cares to look at the records of medical jealousy will see the greatness of a Boerhaave, who could thus refer to an elderly senior. Not always do we find virtue so obviously rewarded as in Boerhaave's case. He became, in Haller's phrase, "the general teacher of Europe." His works were translated into many languages, including Arabic. A letter from China, addressed to "The most illustrious Boerhaave, physician of Europe," was received by him. Peter the Great took lessons from him. He acquired a gigantic fortune by his practice, probably the largest ever made by medical practice, for he left two million florins.

Dr. R. O. Moon, in his "Relation of Medicine to Philosophy," has given us a more just and subtle appreciation of the genius of Boerhaave than perhaps any other commentator. Like Sydenham, Boerhaave saw that medicine, in their time, had become completely divorced from Nature. The doctor had a stock of large and pretentious theories, based on the supposed laws of physics and chemistry. From these he drew his conclusions, and was meanwhile too busy even to look at his patient. We must drop all these foggy and blinding theories, said Boerhaave, and return to what the Father of Medicine taught: we must observe the patient first, and thus begin again at the beginning. This he did, and this he taught his pupils to do. And if he had never made an original observation in his life, this would be sufficient for his fame. From his time onwards, and not least through the influence of other schools of medicine vivified by his pupils, medicine has been based upon the only solid ground, which is direct observation of the facts of natural processes in health and disease.

Though rejecting as nonsense the supposed knowledge of his time, Boerhaave never hesitated to declare that a real science of medicine was possible. Clinical observation was the first necessity; and side by side therewith anatomy and physiology must be studied. Thence, and thence only, he said, could be evolved a science of medicine.

The modern student may rub his eyes when he reads the dicta of Boerhaave—that health consists in the normal action and reaction between the solids and fluids of the body; that in diseases the vessels may be relaxed, causing congestion, or contracted, causing obstruction and suppression of secretions. Today we know these assertions to be true, but we may well marvel at the insight of the man who could enunciate such principles at such a date, and before the existence of any of our modern means of observation.

Yet, for all this, Boerhaave never lost sight of the real needs of medical practice. He did not want to turn out prodigies of learning, he said, but good practitioners, and for him this meant the inculcation of the whole of the noble ideal of Hippocrates, which is moral no less than intellectual. He certainly practised what he preached. He was courteous to everybody, and jealous of no worthy predecessor or contemporary. Every morning he gave an hour to private religious exercises. He was devoted to music, and had a concert in his house every week during the winter. Joy was the salt of life, he declared, but it must be clean and innocent joy. Temperance in all things he consistently taught and practised.

HERMANN BOERHAAVE

After a very long and very painful illness, this truly illustrious man died, on September 23, 1738. His fellow-townsmen built a great church in his honour, and dedicated it to "the health-giving genius of Boerhaave." The visitor to the ancient town which the genius of such men, and the glorious courage of its inhabitants against Spanish oppression, have made famous to the end of time will also remember a fine statue of Boerhaave in one of the principal streets, showing the great teacher as he must have appeared in life, dignified, unpretentious, and venerable. Boerhaave was one of the men before modern science whose character, broad-based on sound judgment and liberal instincts, has appealed successfully to the opinion of later ages.

PAUL BROCA

A Great Student of the Brain

Paul Broca was born in the French Department of Gironde on June 28, 1824, and studied medicine in Paris. There in due course he became Professor of Pathology, and made one famous discovery in that field. At the same time he devoted much study to the science of anthropology, quite apart from any medical questions, and it is indeed as an anthropologist that he is generally remembered.

The skull and the brain were his chief objects of study. He was one of those pioneer anthropologists who believed the shape of the skull to be a crucial and trustworthy criterion of race—a view which is, indeed, still maintained, though the recent work of Boas in America throws much doubt upon it. In France Broca raised physical anthropology to its true dignity as a science, and founded the Anthropological Society and "Review."

Modern thought is especially indebted to him in relation to organic evolution in France. There his authority and intellectual power made him the great champion of the newer ideas represented by Spencer and Darwin, and his propagandist work in this respect compares closely with that of Huxley in this country and that of Haeckel in Germany.

M. Jean Finot, in his "Race Prejudice," provides contemporary readers with a not unjust criticism, however, of many of the conclusions at which Broca and the men of his time arrived. More serious still, we require now to revise some conclusions which Broca reached, and which are acceptable to M. Finot. The distinguished French editor, after referring to Broca's careful and patient methods of skull-measurement, refers to the splendid memoir published by Broca in 1873, wherein the anthropologist compared the head-measurements of the attendants in the hospital of Bicêtre with those of the surgeons and chemists in that institution. Broca found that the latter groups had the more capacious heads, which was doubtless the case. But he drew an inference therefrom: "The education which they have received has exercised their brain and has been favourable to its development." In short, Broca argues that these differences in skull-capacity are due to education alone. But today we know that the innate differences between individuals must be reckoned with, and we cannot accept Broca's conclusion, though we do not doubt his facts.

At the same time, we must not suppose that Broca belonged to the crude phrenological school which was content to assume a direct correspondence between skull-capacity and intelligence. He formally denied such a correspondence; and we owe to him the great pathological discovery which laid the foundations of "cerebral localisation," and will give him a permanent fame when the final history of physiological science is written.

In 1861 Broca published his epoch-making memoir, based upon the study of two cases, in which he declared that loss of speech, known in medicine as aphasia, was associated with injury to and inaction of the posterior part of the third convolution of the frontal lobe of the cerebrum, on the left side. This area is now everywhere known as the speech-centre, or "Broca's area." Of course, Broca could not define the whole truth from two cases, and there was more to follow, but he made the essential discovery, with all that it means. Upon it and those that have followed it rests our knowledge of the fact that the whole brain is not equally concerned in all cerebral observations, but that parts of the brain are specialised for special functions. Speech is, of course, not so simple as was supposed. There is not one speech-centre, but two in illiterate persons, and four in those who can read and write.

Further, though Broca could scarcely make such a discovery from two cases, we find that the speech-centres are upon the left side of the brain only in right-handed people, and are upon the right side of the brain in left-handed people. Hence, numerous cases soon came to be published in which Broca was apparently wrong, and his discovery proved to be no discovery, for aphasia was present, but "Broca's area" was intact. Time was needed to show that Broca was essentially right, but that the qualifying phrase, "in right-handed people," was necessary in order to make his statement exact.

More than fifty years have passed since this great discovery, which is just one more instance of the importance of exact observation. Sir Francis Galton records how he searched the archives of medicine in vain for a single reference, before Broca wrote, to the fact that paralysis of the right side of the body is commonly accompanied by loss of speech. Innumerable cases must have been offered to the observation of physicians, but they had all been "missed," as we now say. Broca did not miss his cases, but took the whole of his opportunity, and laid the foundation of our modern knowledge, copious, varied, precise, practically invaluable, yet more mysterious than ever, of the functions of the cerebrum.

Broca died in Paris on July 9, 1880, at the comparatively early age of fifty-six, but he lived to see the science of cerebral functions, which he founded, much advanced and consolidated. Visitors to Paris who cross the Seine on the way to the Luxembourg may turn a little aside, and will find a statue of Broca in the Boulevard St. Germain, near the School of Medicine.

SIR DAVID BRUCE

A Clearer-Up of Great Mysteries

Surgeon-General Sir David Bruce, of the Army Medical Staff, is renowned for his discoveries of the causes of various terrible tropical diseases. He is a Scotsman of Australian birth, having been born in Melbourne on May 29, 1855. In boyhood he became an enthusiastic naturalist, and to this early study of the curious ways of insects and animals he largely owes his present high importance in medical science. His youthful hobby became vitally connected with his later studies as a doctor, when he found that gnats and flies were the carriers of some of the most deadly maladies. Sir David was educated in Stirling High School, and he went on to Edinburgh University, where he was trained in medical science and took the M.B. degree. In 1883 he obtained his commission in the Army Medical Staff, and for six years served in Malta and Egypt.

It was in Malta that he made his first great discovery. At that time our soldiers suffered dreadfully from a mysterious disease known as Malta fever. It is one of the plagues of the Mediterranean region, and the inhabitants of all the lands washed by the great inland sea are liable to its deadly attack. Sir David Bruce, by an ingenious line of research, conducted at considerable personal danger, traced the malady to the milch goats kept at Malta for supplying the garrison with milk. Then he went on to study the milk and the blood of these animals, and in them he found the germ of the disease. At the present time the Malta fever germ is one of the two most perilous things handled in the medical laboratories of Europe. It ranks with the germ of glanders, and only the most highly skilled men dare examine it. And even they, with all their care, do not escape. When, in 1889,

Sir David became Assistant Professor of Pathology at the Army Medical School at Netley, under Sir Edward Almroth Wright, he continued his researches on Malta fever. The disease never attacked him, but Wright fell a victim to it, and so did another man working in the laboratory. Wright, however, survived, and a treatment of the disease by vaccination was found to produce good results.

In 1894 Sir David Bruce left Netley and proceeded to Natal in the course of his military duty. While visiting the north of Zululand, he became deeply interested in the tsetse-fly disease, that attacked and killed horses, cattle, and dogs brought into certain regions of South Africa. Everybody thought that the destruction of farm stock was entirely the work of the fly, that was supposed to inject a poison into the animals upon which it alighted. Sir David Bruce, however, opened up a new field in medical science by ascertaining that the fly was merely a carrier of disease. For he discovered a microscopic animal with a screw-like body, now known as "trypanosoma brucei," and he proved that this was the real cause of the cattle plague.

The parasite lived in the blood of the wild animals of South Africa without doing them any harm. The tsetse-fly fed on this blood and swallowed the living parasites, and introduced them into domestic beasts while sucking their blood. Sir David Bruce gave a valuable and practical application of his discovery, by pointing out to the South Africans that the cattle disease could be prevented by killing off or driving away all the wild animals that acted as a reservoir of the disease, for the tsetse-fly then became harmless.

But his work had a more profound and larger application than this. By it he may be said to have laid the foundation of most of the discoveries which have since been made in regard to the part played by insects in the propagation of malaria and other diseases. Unhappily, the outbreak of the South African War completely interrupted his special researches. Together with his wife, Lady Bruce, who had taken an active part in all her husband's discoveries, particularly in connection with the microscopic work, he was shut up in Ladysmith at the beginning of the war. He remained in the town during the long siege, and for his services he was mentioned in despatches and promoted to the rank of lieutenant-colonel. After working on a commission sent out from England to investigate the cause and prevention of dysentery in armies in the field, he was lent to the Foreign Office for work in Uganda, and his second period of discovery began.

The terrible disease of sleeping sickness had spread from the Congo region to Uganda and the Nile. The ten thousand natives whom Emin Pasha had brought from the Congo to Uganda had carried the disease with them. There was danger that it would rapidly spread from Lake Victoria and Central Africa to the Zambesi and parts of the Transvaal. The Foreign Office wanted Sir David to prevent this, and make tropical Africa a country in which natives and white men could live. Dr. Dutton had recently lost his life while studying the disease; but, before his heroic death in the cause of humanity, Dutton had found that a minute, worm-like creature brought about the fatal sleep by attacking with its poisons the brain and spinal cord.

Sir David Bruce continued Dutton's work by making large collections of all the biting flies of Uganda. By this means he discovered that the distribution of sleeping sickness corresponded exactly with the distribution of a biting kind of tsetse-fly that bit human beings. Then, by a series of conclusive experiments, he proved that this fly carried the disease parasite, and introduced it into the blood of white men and natives when it bit them. So the problem of saving the whole of Africa and India from the sleep of death was reduced to the problem of killing one kind of fly. It is not improbable that the deadly disease-carrier has spread from its home on the Congo owing to the criminal destruction of birds by plumage hunters, for it has already been found that one kind of fly that spreads the malady is eagerly discovered and devoured by guinea-fowls when it is in a larval state close to the roots of certain trees.

After clearing up the mystery of sleeping sickness, Sir David Bruce, in 1911, went to Nyassaland, as director of the Royal Society's Commission, to investigate the connection between wild animals and the tropical diseases attacking human beings and domesticated animals. If it is proved that the wild beasts of the tropics act as reservoirs of disease, by carrying in their blood, without harm to themselves, the germs of dreadful maladies that are making South Africa uninhabitable, it may be

necessary for the sake of humanity to destroy all the large game of the affected regions. Sir David Bruce married, in 1883, Miss Mary Steele, who has, wherever possible, acted as her husband's assistant and shared in his scientific work.

COUNT BUFFON
An Early Champion of Evolution

George Louis Leclerc, afterwards made the Comte de Buffon, was born in Burgundy on September 7, 1707. After studying law and science, and making a grand tour, which included England, he became director of the King's Garden in Paris, and deter-

BUFFON READING HIS NATURAL HISTORY TREATISE

mined to write his celebrated "Natural History," which was ultimately produced in fifteen volumes.

This was an encyclopædia and, at the same time, a philosophy of the subject. Buffon was a master of language, with an ambitious mind, and his project was to present the whole of animated nature in the most magnificent literary form. As to the quality of his writing there is no doubt. Long before Carlyle he said that "Genius is only an unusual aptitude for patience," and we owe to him the epigram, "The style is the man himself," which is usually misquoted and misunderstood by the suppression of the last word. He performed a lasting service for natural history by giving to the subject so magnificent and extensive a treatment. That was a great step forward, when the study of living nature was regarded as beneath the dignity of true philosophy and culture, as it is by many people even today.

But a work so ambitious and grandiose, produced at such a date, with such resources, and by an author concerned above all to produce a magnificent monument, could not possibly be as inherently valuable as its size and pretensions suggested. "Travellers' tales" play far too large a part in it. The author wanted to include everything that was known, and even if it was not really known. We cannot, therefore, go to Buffon as an authority upon questions of fact in natural history. Yet we owe to him at least the lesson that natural history is second to no other science in dignity and interest, and that the characteristics and behaviour of all kinds of living creatures are worthy of study even by man.

Lastly, the name of Buffon is one of the few in the illustrious line of those students of the living world who maintained, before the nineteenth century, the doctrine of organic evolution as against the dogma of special creation. He saw and taught that the animal kingdom reveals a succession of forms, derived from one another; and we owe to him the bold and plausible idea that the first forms of life were naturally produced upon our planet in the ocean, and in the Polar regions, where the water would first be cool enough for life as we can imagine it to exist. Twenty-one years after the completion of his masterpiece, Buffon died in Paris, on April 15, 1788.

W. B. CARPENTER
The Discoverer of the Sub-Conscious Mind

William Benjamin Carpenter, the son of a famous Unitarian minister, was born at Exeter on October 29, 1813. His sister, Mary Carpenter, made no contributions to science, but she drafted a Bill for national education in the 'forties of the nineteenth century, and her remarkable life must be placed beside that of her brother in any study of the natural history of talent, moral and intellectual.

Young Carpenter began the study of medicine, and took his doctorate in Edinburgh in 1839. Five years later he was elected a Fellow of the Royal Society, and in the following year he became Professor of Physiology in the Royal Institution. There, and in his volumes published for the general reader, he showed his rare powers of exposition, and of saliently and clearly presenting, in due

proportion, the essential features of a subject. His "Principles of Physiology," first published in 1838, and revised by its author from time to time, was the accepted authority on its subject in this country for several decades, and is frequently quoted still. The present-day student who refers to it will agree that it deserved all its fame.

Dr. Carpenter was an evolutionist, and a keen microscopist, but he was not a materialist. On the contrary, he always maintained the reality of the mind. Like Shakespeare's Malvolio, he thought nobly of the soul; and he studied mental action so closely as to recognise what he called "unconscious cerebration," or, as we now say, "the sub-conscious mind." In this he was a true pioneer, and stands apart from all his physiological contemporaries. Modern psychology is concerned above all with the study of that which Carpenter was the first clearly to recognise and name. Dr. Carpenter died in London on November 19, 1885, as the result of a tragic accident with a spirit-lamp.

JEAN MARTIN CHARCOT

A Great Master in Nerve Treatment

Jean Martin Charcot, the great French expert in nerve diseases, was born in Paris on November 29, 1825. After a general and medical education, he began, in 1862, to work at the Salpêtrière, the institution which he has made so famous.

His work lay in the realms of nervous disease, and led, like all faithful research in pathology, towards a better knowledge of health, and of the normal characteristics of mind and body. Thus his name will always be remembered in association with a strange and significant affection of the joints which is known as "Charcot's disease." He found that this general disintegration of the structures of, for instance, the knee-joint occurred as a "complication" of certain degenerations in the nervous substance of the spinal cord, to which we give the name of "locomotor ataxia." The meaning of the discovery is that the joints, like all other parts and tissues of the body without exception, depend for their health upon the healthy activity of certain nerves, which exercise a nutritive or "trophic function." How these trophic nerves act, we cannot say, but the discovery of this function of the nervous system was a most important one.

More famous still, among the public in general, are Charcot's researches into hysteria, conducted as they were by a man of extremely high prestige, and among an impressionable and superstitious type of patients. Much of what Charcot taught requires modification, and modern writers on the subject regard him as having opened rather than closed the subject, but the study of hypnotism could not be in its present state without him. The present French school of neurologists, famous everywhere, owe a great debt to this notable pioneer. He died in the district of Morvan on August 16, 1893.

SIR THOMAS CLOUSTON

The Mental Side of Adolescence

Sir Thomas Clouston was born in the Orkneys, on April 22, 1840, and studied medicine in Edinburgh. He early specialised in diseases of the mind, and was for many years Physician Superintendent of the Royal Morningside Asylum, Edinburgh, and lecturer on mental diseases in the university. His clinical lectures have passed through numerous editions, and are among the most widely studied and highly valued text-books on insanity throughout the world, He has been President of the Royal College of Physicians of Edinburgh, and was knighted in 1911.

Clouston is honoured by medical men all over the globe as an inspiring, original, and sympathetic teacher of psychiatry. He described many years ago what he called "phthisical insanity," a form of mental alienation due to intoxication by certain unknown substances added to the blood-stream in some cases of consumption; and he is one of the foremost medical opponents of alcohol. on account of its action upon the functions and stability of the brain. Since his retirement from official work in Edinburgh he has written a volume on "The Hygiene of Mind," which contains the ripe judgment of an author who speaks with almost unrivalled authority and experience. This book has greatly extended the author's former fame. His interest in and enthusiasm for mental health, especially by the wise direction of adolescence, are inexhaustible, and for the last few years he has spent much time in writing and lecturing in London and Edinburgh for the National Council of Public Morals, and its journal, "Prevention," where his contemporary work is now to be found.

GEORGES CUVIER

The First Student of Fossil Remains

Georges Cuvier, the most widely known zoologist of the early nineteenth century, was born on August 23, 1769, at Montbéliard,

of Huguenot ancestry, his mother being a most exceptional and devoted woman. At the age of twenty-six he began to work in the Jardin des Plantes, in Paris, thanks to the help and influence of Geoffroy Saint-Hilaire, who is remembered for his leanings towards the now accepted theory of organic evolution.

Many and substantial honours, scientific, social, political, awaited him. He became permanent secretary of the Institute of France and Chancellor of the University of Paris. During one period he lost Royal favour, on account of his championship of freedom of the Press, but under a new king he obtained greater honours than ever.

Throughout his life Cuvier was an indefatigable worker. With this faculty for work there went a most tenacious memory, so that the range of facts in natural history upon which he could draw at any time was enormous. This was before the days of systematic record-making, the use of the card system by men of science, and so forth. Cuvier had more facts of zoology in his head than anyone else, and his reputation very soon became supreme, with very serious consequences for knowledge.

Cuvier was a copious and conscientious writer. His most famous work, upon "The Animal Kingdom," represents a splendid attempt to improve our classification of animals according to their structure. This, of course, has been the aim of zoologists ever since the time of Aristotle; and Cuvier was certainly, of all men of his time, the best qualified, by his encyclopædic knowledge, for the task. In several ways, subsequent zoology is much indebted to him, but his four-fold division of the animal kingdom was far too rigid and simple to satisfy extending knowledge.

The name of this great observer is particularly associated with the study of the fishes, five thousand species being described in his volumes on the subject. With these he had some help, but the directive and driving powers were his, and his work is a monument of devotion. Similar productions at the present day are the work of an army of specialists, each of whom works at his portion of the task with ant-like devotion. Cuvier was many such men in one.

Above all, he was a student of fossils. The study of the fossil remains of animals, now called palæontology, has never had a student to rival Cuvier. Today this science ranks higher than ever, thanks to many discoveries made since his day, and palæobotany has become its parallel on the vegetable side. Cuvier was the first student of the extinct mammals, and it will be readily understood how his description of these remarkable remains increased his fame. To him fell the opportunity of being the first to describe the fossil remains of such creatures as the cave-bear, mastodon, extinct forms of the rhinoceros and elephant, and hosts of other creatures besides that were strange to the men of his day.

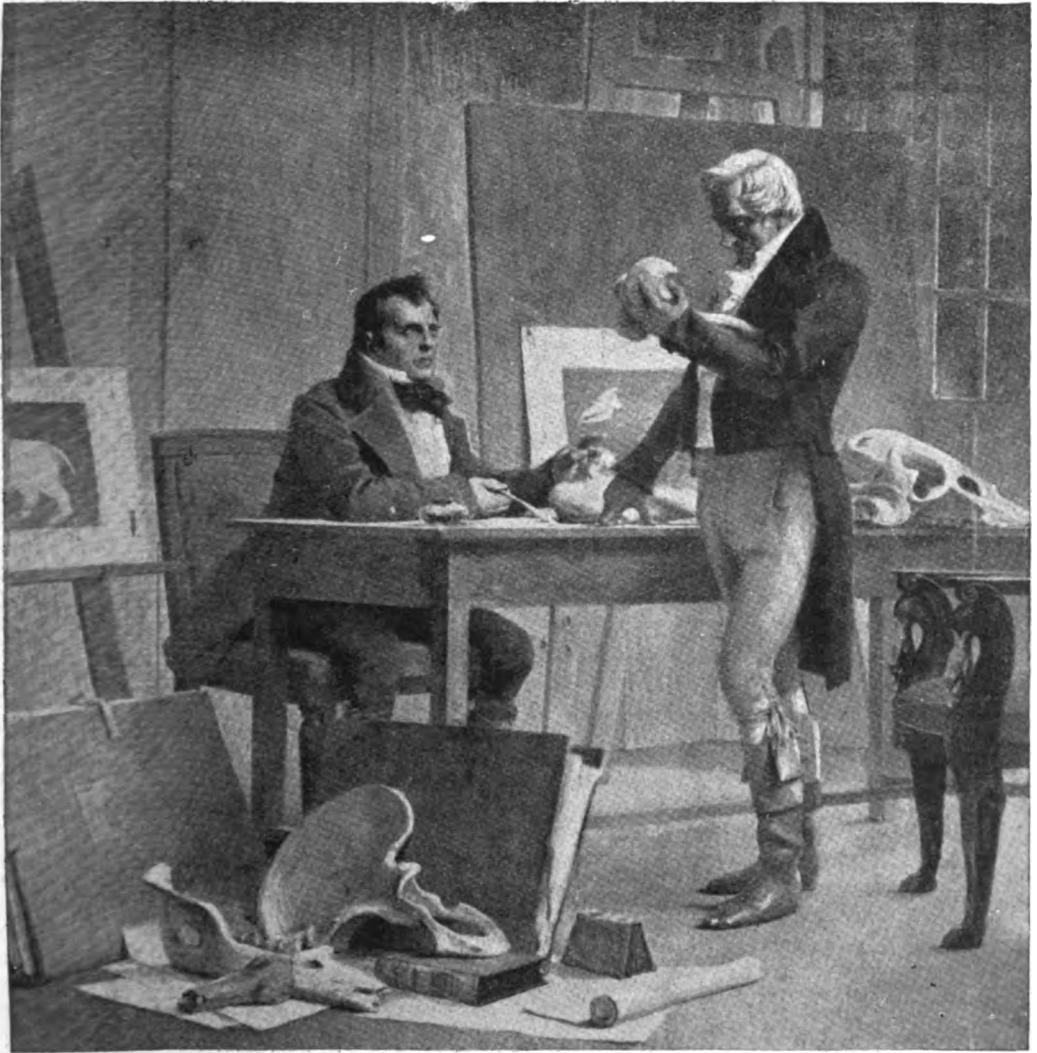
The results of all these researches are to be found in his chief work already referred to. His great predecessor, Linnæus, the father of all systematists, had not been able to divide invertebrate animals into more than two categories—the insects and the worms. Cuvier could and did improve upon that; and at any rate he taught, or reaffirmed, the lesson that we cannot classify animals unless we are prepared to study their individual structure as minutely as possible, and to trust to no foundation less secure than an anatomical one.

He is indeed the great master of comparative anatomy. His inexhaustible interest in his subject, and his powers of work, helped him to demonstrate that we must study various living forms beside one another, and try to recognise those structures which are similar, or analogous, in each. It was from such studies as these that Cuvier was enabled—with much less accuracy than he or his contemporaries supposed—to reconstruct, in imagination, the bodily structure and form of extinct animals, from the study of very small portions of their fossilised skeletons. Arguing that the size of one part was "correlated" with the size of others, he ventured to define the whole of the animal from the part in this fashion.

The amazing fact remains that, from first to last, Cuvier consistently opposed the theory of organic evolution, of which no man before his time had more palpable or abundant evidence daily displayed before him. We are apt to regard the theory of the descent of living forms as an invention of Darwin's. It was, of course, stated by Darwin's grandfather, Erasmus Darwin, by Goethe, by Cuvier's contemporary Lamarck, and by many thinkers besides. The idea was perfectly familiar, and was commonly discussed by the leaders of natural history, before Darwin was born. We can only surmise to what extent Cuvier remained to the end under the influence of the religious teaching that he had received from his

mother, which doubtless included very definite statements as to the Divine and exact authority of the Book of Genesis.

Anyhow, it is the fact that this great student of fossils, with his unprecedented survey of the animal kingdom, in time and space, championed ardently the doctrine of the fixity of species—upon which, indeed, his entire system of classification reposed species were fixed, organic evolution was a myth, and special creation a fact.

In truth, with his great powers in certain directions, Cuvier was not a natural philosopher in any real sense of the term. No one has ever excelled him in observing and recording, but interpretation is a very different matter. It is the difference between sight and insight; Cuvier had the

CUVIER, THE FIRST STUDENT OF FOSSIL REMAINS, AT WORK IN HIS LABORATORY

The theory of organic evolution thus found itself met by the supreme naturalist of the age, with the inevitable consequences. Its representatives, who argued that living forms changed, were met by the master of palæontology, who quoted the form of fossils, notably in Egypt, which were closely similar to living forms. Therefore, one, but Lamarck had the other. Cuvier wished to systematise the forms of the living world, and did so. But where would his systems be if species were not fixed, and the types which he described could change into one another? He would not have it so. It would have shattered his scheme.

Had Cuvier never lived, or had he been

endowed with deeper powers of mind, the doctrine of organic evolution would doubtless have triumphed half a century sooner than it did. Perhaps the nearest parallel is the long delay in discovering the "undulatory" theory of light, due to the fact that the supreme Newton had recorded his verdict against it.

Cuvier became Minister of the Interior in 1832. He worked hard and wisely at schemes for national education, but died on May 13, 1832, in the same year as Goethe and Sir Walter Scott.

CHARLES DARWIN

The Man who Shook the World of Thought

Charles Robert Darwin was born at Shrewsbury, on February 12, 1809. His father, Dr. Robert Darwin, was a successful physician, often described by his illustrious son as "the wisest man I ever knew." Charles Darwin's mother was the daughter of Josiah Wedgwood, and Dr. Robert Darwin was the son of Erasmus Darwin. According to Sir Francis Darwin, "we may hazard the guess that Charles Darwin inherited his sweetness of disposition from the Wedgwood side, while the character of his genius came rather from the Darwin grandfather."

Darwin's mother died when he was eight, and in this year he went to a day-school in Shrewsbury, of which he says, in the priceless autobiographical sketch written for his children, "By the time I went to this day-school my taste for natural history, and more especially for collecting, was well developed. I tried to make out the names of plants, and collected all sorts of things—shells, seals, franks, coins, and minerals. The passion for collecting which leads a man to be a systematic naturalist, or virtuoso, or a miser was very strong in me, and was clearly innate, as none of my sisters or brother ever had this taste."

In 1818, Darwin went to "Dr. Butler's great school in Shrewsbury," and stayed there for seven years His master condemned him as entirely dull, and his own mature verdict, not written for publication, is as follows—"Nothing could have been worse for the development of my mind than Dr. Butler's school, as it was strictly classical, nothing else being taught, except a little ancient geography and history. The school as a means of education to me was simply a blank. When I left the school I was for my age neither high nor low in it; and I believe that I was considered by all my masters, and by my father, as a very ordinary boy, rather below the common standard in intellect."

At school young Darwin loved poetry, a taste he later lost, and he also enjoyed a book called "The Wonders of the World," which gave him the wish to travel, ultimately fulfilled by the voyage of the "Beagle." From his useless school he went to Edinburgh to study medicine, but with little success. He never began dissection, and he could not draw, two disadvantages which he describes as "irremediable evils" for his life-work. He saw two operations, one on a child, but had to rush away before they were done, "this being long before the blessed days of chloroform." It is interesting to note the ever-recurrent evidence of humanity and kind-heartedness in this man, who tells us that his humane ideas were entirely derived from his sisters' tuition, and that he doubts "whether humanity is an innate or natural quality."

But Darwin was not destined by nature for medicine, and soon he and his father agreed that he should become a clergyman, so he left Edinburgh for Cambridge, where he found that he had actually forgotten even the Greek alphabet. As he tells us, "My time was sadly wasted then, and worse than wasted." He shot and hunted, and rode and dined, "and we sometimes drank too much." But he learned to love music, especially the anthem at King's College Chapel, which would sometimes make his backbone shiver, a fact which puzzled him, for he could never hum a tune, or even recognise "God Save the King" when played rather slower or faster than usual. Collecting beetles, however, beat hunting and driving and music, for Darwin at Cambridge. One of his sporting friends, seeing him at his beetles, told him he would one day be a Fellow of the Royal Society, "and the notion seemed to me to be preposterous." At Cambridge he read Humboldt and Sir John Herschel, and in 1831 he went as unpaid naturalist on the voyage of the "Beagle," which he describes as "by far the most important event in my life."

For five years the young naturalist observed and recorded, observed and recorded; and soon after his return home—in July, 1837, to be precise—"I opened," he says, "my first notebook of facts in relation to the 'Origin of Species,' about which I had long reflected, and never ceased working for the next twenty years."

In 1839, Darwin married his cousin, Emma Wedgwood, a fact worthy of note,

DARWIN DISCOVERING A FOSSIL MASTODON IN AMERICA ON HIS VOYAGE ROUND THE WORLD

E. M. SHELDON

DARWIN WATCHING AN ANT-LION TRAPPING ITS PREY

for from these cousins there sprang the family which includes the late Sir George Darwin, Sir Francis Darwin, Mr. Horace Darwin, and Major Leonard Darwin, all notable and able men. He was a devoted husband and father. No one who has any vestige of feeling for beauty of character should omit to read the chapter "Reminiscences," in Sir Francis Darwin's Life of his father. His children adored him. His devoted wife tended him unfailingly throughout the cruelly harassing nervous dyspepsia which never left him. This alone made his life and work possible, as Sir Francis thus records: "For nearly forty years he never knew one day of the health of ordinary men, and thus his life was one long struggle against the weariness and strain of sickness. And this cannot be told without speaking of the one condition which enabled him to bear the strain and fight out the struggle to the end."

He loved dogs without limit; indeed, he had a feeling for every living thing, and personified them, one and all. Says his son: "I used to like to hear him admire the beauty of a flower; it was a kind of gratitude to the flower itself, and a personal love for its delicate form and colour. I seem to remember him gently touching a flower he delighted in; it was the same simple admiration that a child might have." Sir Leslie Stephen, comparing Dean Swift's observations on servants with those of Darwin on worms, says: "The difference is that Darwin had none but kindly feelings for worms." These facts are interesting when we remember the purely mechanical theory of living creatures which has been erected upon Darwin's writings, and is known as Darwinism.

The writings themselves are implicit in the whole of modern biology, and no discussion of life in general, or of any of its aspects, can now be written without constant reference to them. Here, therefore, we merely note, for form's sake, the publication of the "Origin of Species," in 1859; "The Descent of Man," in 1871; "The Expression of the Emotions in Man and Animals," in 1872, among several works of less importance.

This man, whose works aroused the most fierce and unremitting controversy in the history of knowledge, was himself as gentle as one of the flowers he loved. He never entered into controversy himself, though he found doughty champions in Huxley, Haeckel, and others. His personality and his own teaching were widely different from the doctrine which goes by his name, and which modern biology has already relegated to an entirely subordinate position, of no central moment in the problems with which it professed to deal.

What Darwin called "natural selection" as an explanation, *in part*, of adaptation is the true Darwinism, which Darwin himself taught. This doctrine stands today, so long as no more is piled upon it than its author gives us warrant for. But we have finally abandoned the ingenuous notion of the nineteenth century that Darwin had closed any chapter in biological theory. It is to his lasting credit that he boldly, honestly, unweariedly opened many, but he closed none.

He was a supremely great observer, but not strictly a thinker. Though he was a student of life, from first to last, he never framed or seemed desirous of framing any ideas as to the nature of life, which is, after all, the essential problem of biology. He tells us that his mind soon became lost when he embarked upon abstract conceptions. But, though his work is used as the great argument against Design, and though the opposition between Paley and what is called "Darwinism" is absolute, he once recorded his "inward conviction that the Universe is not the result of chance."

This great man, morally and in all essential qualities of mind as near perfection as we can imagine, the very exemplar for all time of what the student of Nature should be, a man whose daily life and character are a sufficient illustration of the impotence of "Darwinism" to explain the supreme phenomena of Life and Mind, died on April 19, 1882, and, to the credit of his contemporaries, was buried in Westminster Abbey, where his mortal remains lie close to those of Newton.

ERASMUS DARWIN
The First Poet of Organic Evolution

Erasmus Darwin was born at Elton, Notts, on December 12, 1731. He graduated in medicine at Edinburgh, and soon became a very successful practitioner in Lichfield.

But we do not remember him as a doctor, though he may be honoured for the horror of drunkenness which his illustrious grandson Charles Darwin shared. Erasmus Darwin was essentially a man of science, though his contemporary reputation was that of a poet. Today we do not find any of the essentials of poetry in "The Loves of the Plants," though it is written in metre, and abounds in classical metaphors and mythological allusions. The

only feature of this poem which interests us is the fact that it reveals, in the grandfather, exactly the same love of and interest in living creatures which we find in the grandson. This sympathetic observation also led Erasmus Darwin to the view that, even in vegetable organisms, signs of sensation, and even of will, may be found. This opinion has its own historical interest, too, for it anticipates, in some degree, Sir Francis Darwin's observations.

But, above all, Erasmus Darwin is to be remembered for his famous anticipation of the theory of organic evolution. In his boyhood Charles Darwin read his grandfather's views, and they must have helped him to liberate himself from the accepted

ERASMUS DARWIN

doctrine of the fixity of species, but on later reading Charles Darwin candidly admitted that he found his grandfather's views somewhat disappointing, owing to the excess of speculation over fact.

In 1781 Erasmus Darwin went to live in Derby. He was twice married, with very notable consequences, for by his first wife he became the grandfather of Charles Darwin, and by his second of Francis Galton, thus furnishing very conspicuous illustrations of what his younger grandson, when making the first serious attempt to place the problem of heredity permanently upon a scientific basis, was to call "eugenic marriages."

He died at Derby on April 18, 1802.

SIR FRANCIS DARWIN

A Great Investigator of Plant Life

Sir Francis Darwin, the third son of Charles Darwin, was born at Down, in Kent, his father's famous home, on August 16, 1848. He was educated at Cambridge and in London, taking a medical degree, but became his father's helper, and so remained until 1882, when his father died. Since then he has lived in Cambridge, where for some time he was Reader in Botany. He was President of the British Association in 1908, and was knighted in 1912.

Sir Francis Darwin's name and work will always be associated chiefly with his father's. His biography of his father is a fine piece of work, and its many admirers were much gratified when, in 1903, Sir Francis issued two more volumes entitled "More Letters of Charles Darwin," which are crammed with valuable and interesting matter. In 1909 Sir Francis also published a short work, "Foundations of the 'Origin of Species,'" dealing with the genesis of the famous volume of which the jubilee was celebrated in that year.

Sir Francis's botanical textbooks are less interesting than some of his own remarkable researches into aspects of botany which did not much enter into his father's work. As early as 1876, when he was living with his father at Down, he began his researches into the functions of plants, and he has been able to show the fashion in which plants are aware of and adapt themselves to the force of gravitation. Indeed, it is not too much to say that his work has tended decidedly away from what is usually misnamed "Darwinism," and agrees much more closely with the fashion in which both his father and great-grandfather Erasmus were wont to look upon the behaviour of plant organisms.

C. B. DAVENPORT

A Master of the Facts of Heredity

Charles Benedict Davenport was born at Stamford, Connecticut, on June 1, 1866, and began the study of science at Harvard University, where he took the doctorate in philosophy in 1892. During some years, while he was teaching zoology in various American universities, he began the experimental study of the conditions of growth and development. His first book was on "experimental morphology," and later he became attracted to those statistical methods which seemed, at the end of the nineteenth century, to be the most promising instrument for progress in biology.

Then came the rediscovery of Mendelism, with its obvious demand for new researches in heredity by actual breeding experiments. Hence, since 1904, Dr. Davenport has been director of the Station for Experimental Evolution of the Carnegie Institution of Washington, and there, during several years, he experimentally investigated the facts of inheritance in fowls, canaries, etc. He thus became recognised as the leading Mendelian worker in America, and it was inevitable that his work, sooner or later, should take cognisance of the problems offered by man.

In 1909, thanks to an impulse from this country, interest in eugenics became aroused in the United States; and late in the following year the Eugenics Record Office was established, beside the station of the Carnegie Institution in Long Island, New York, by the Eugenics Section of the American Breeders' Association, with Dr. Davenport as its secretary. Since that date Dr. Davenport has devoted himself increasingly to eugenic research, with conspicuous success. He has written a popular volume on the subject, and has set in motion a large amount of first-hand work, with the aid of "field workers" trained by himself for the purpose. The publications of this Office now include eight bulletins and two memoirs, and have already shed light on many problems in human heredity. Particularly notable is Dr. Davenport's study of the heredity of epilepsy, published in 1911, and he contributed a paper on "Marriage Laws and Customs" to the Eugenics Congress in London in 1912. He has made his Record Office by far the most important centre of research in the world for the study of human genetics.

HUGO DE VRIES

A Scientist who Believes in Jumping Changes

Hugo de Vries was born at Haarlem in 1848, and is now Professor of Plant Anatomy and Physiology in the University of Amsterdam. His writings have won him great academic honour in his own and other lands. De Vries stands for the idea that new species naturally originate in the living world not by the slow accumulation of minute differences, but by the sudden appearance of new forms. His world-wide fame dates from the publication, in 1901, of his great book "The Mutations Theory." In it he argues that we have hitherto neglected those stable, sudden, and usually large changes in species which he calls mutations, as distinguished from the minute, unstable differences which he has now taught us all to call fluctuations. This theory of De Vries was mainly based on some observations which he made upon the evening primrose and its behaviour in a state of nature. Upon his work there came to be founded a school called the "Mutationists," who are, or were, obviously allied to the Mendelians, both of them being distinguished by their appreciation of the importance of distinguishing, as Darwinism did not, between differences that are inheritable and the mere fluctuations that are not.

It is not too much to say that the experiments and observations of the great Dutch botanist have inaugurated a new epoch in the history of biology. In the first place, he was one of the three botanists who published independent papers in the spring of 1900 and rediscovered the work of Mendel; and his own contributions have been overshadowed in importance only by the long overlooked experiments of the great man to whose work he directed us.

HANS DRIESCH

A Philosopher who Finds Intelligence in All Life

Hans Adolf Eduard Driesch, the leader of a young but interesting school in modern science, is the son of a Hamburg merchant. He was born at Kreuznach, in Rhenish Prussia, on October 28, 1867. He studied at Hamburg till nineteen, and then went to various German universities; but it was two periods of travel in tropical Asia, through Ceylon, India, Burmah, and Java, that gave his mind its special bent towards the study of the force of life. He also spent nearly nine years in the continuous study of experimental biology at the Zoological Station of Naples.

It is largely on the facts and ideas which he obtained at Naples that his remarkable views on life are based. He has made various visits to Naples since he settled, in 1900, at Heidelberg, of which university he was appointed, in 1911, Professor of Philosophy. For he is a philosopher with a set of ideas that are furiously attacked and ardently defended, and he tries to keep in touch incessantly with the study of living forms on which his system of thought is built.

He had a brilliant reception from many leading Scotsmen when he came to Aberdeen, in 1907 and 1908, to deliver the course of Gifford lectures, in which his remarkable and hotly contested ideas of life were explained at great length. He is opposed to

men like Dr. Schäfer, who try to reduce the whole of life to the interaction of physical and chemical forces. He asserts that when all that is mechanical in the life-force is described, there still remains something over. He identifies the principle of life with some directive activity of a spiritual sort, and he brings together a series of striking facts supporting his view.

Among them are Semon's observations on memory in plants, which have lately been developed in masterly fashion by one of Charles Darwin's sons. And more important still is Herbert Jennings's account of the behaviour of the stentor, one of the very lowest of organisms When a stentor was sprinkled with a disagreeable powder, it did not persist in merely reacting against the strange stuff in an unvarying manner, as it might have done on the mechanical theory. It employs a rational method of trial and error. Finding it could not cleanse itself by one means, it tried another and yet another, until it succeeded in its object. Its movements were neither reflex nor instinctive—they were governed by something strangely like intelligence. When the stentor was cut into minute pieces, one twenty-seventh part of it was able to grow and evolve into an entire living creature. Surely there was some directive principle in this fragment of living matter which enabled it to redevelop in so unexpected and marvellous a fashion?

CHARLES DARWIN'S HOUSE AT DOWN, KENT, THE BIRTHPLACE OF SIR FRANCIS DARWIN

On the base of facts such as these, Dr. Driesch has built a theory of life as a self-directive principle which uses the mechanism of the universe for its own purpose. Suggestive and interesting as Dr. Driesch's views are, he appears to overlook some important facts. Chief among them is the existence of much waste and misdirection in life, of which some explanation is afforded by the theory of natural selection. Dr. Driesch is not a clear writer, and it is possible that his want of clearness in expression is partly due to a want of clearness in thought, but, though he has his limitations, and can only give a partial explanation of the riddle of life, there are some stubborn facts behind his vigorous attack on the mechanistic school.

SCENES FROM THE LIFE OF COLUMBUS

COLUMBUS EXPOUNDING HIS PROJECTS IN VAIN TO THE CLERICAL COUNCIL OF SALAMANCA

COLUMBUS ABOUT TO SET SAIL INTO INFINITY FROM SALTES, NEAR PALOS, ON AUGUST 3, 1492

THE DEATH OF COLUMBUS AT VALLADOLID, WORN OUT BY HARDSHIP AND NEGLECT, MAY 20, 1506

CONTINUED FROM 4405 CONTINUED ON 4633

EXPLORERS

ROBERT O'HARA BURKE

The Second Explorer to Cross Australia

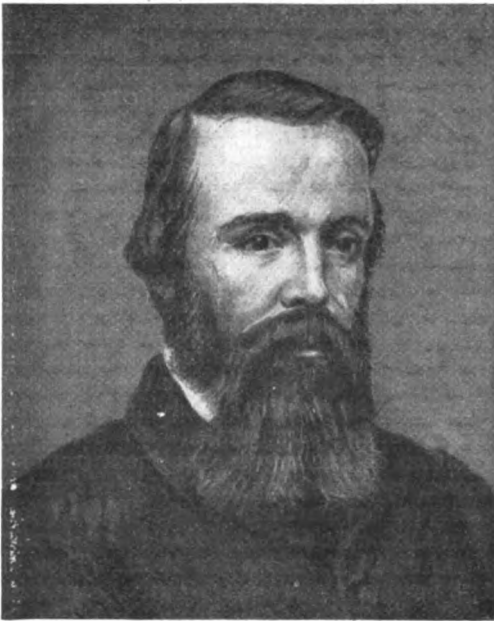
ROBERT O'HARA BURKE, who at the cost of his life won the honour of being the second man to cross Australia northward from sea to sea, belonged to a family of Irish soldiers, remarkable for their bravery. He was born in 1821 at St. Cleram, in the county of Galway, and in accordance with family traditions entered the army, studying as a cadet at Woolwich Academy. In search of adventure, he enlisted in the Austrian service, joining the Hungarian Hussars, with whom he quickly won a lieutenancy. At twenty-seven, however, he returned to Ireland, and obtained an appointment in the Irish Constabulary, but five years afterwards went forth again, in search of adventure, to Australia. The outbreak of the Crimean War brought him home, but, finding he was too late to take part in the fighting, he returned to Australia, where he had won a position of police inspector in Victoria.

Here at last he obtained the opening into the world of wild adventure for which he had been seeking all his life. The people of Victoria had the wealthiest and most important of the Australian colonies, and in 1858 felt that they ought to take a large share of the work of exploring the southern continent, and discovering new lands for settlement. They raised a large sum of money to fit out an exploring expedition, and Burke was appointed leader. He took with him William John Wills, a Devonshire man attached to the Melbourne Observatory, and fourteen other men, one of whom was a native of India in charge of the camels that had been imported for desert travelling. On August 20, 1860, the exploring party left the Royal Park at Melbourne, and crossed the territory of New South Wales, establishing their first depot at Menindie. Here two of Burke's chief men resigned at the moment when the actual dangers of the exploration began; so he engaged a cattle-man from Darling River, Wright, who offered to guide the party to a point 400 miles farther on, known as Cooper's Creek. The route was found to be excellent; it ran through grass-land, with water-holes only twenty miles apart at the most.

Burke was so pleased with Wright that he sent him back with the express order to bring up the stores as rapidly as possible from Menindie to Cooper's Creek. Unhappily, Wright disobeyed this order, with the result that the men who trusted him went forth into the desert to a most terrible death. Cooper's Creek—a sort of inland lake—was reached on November 11; it was the fifty-seventh camping-place of the exploring party. An attempt was made to find water in the northern wilderness, but after travelling for ninety miles and losing some of their camels the men were compelled to return. Early in December Burke made arrangements to solve the problem of crossing the continent from sea to sea, by proceeding to the Gulf of Carpentaria, on the northern coast. He left four men at Cooper's Creek, with orders to stay there until provisions ran short. Then, at the head of the advance party, consisting of W. J. Wills, John King, and Charles Grey, he set out on his journey to death.

It was on December 16, 1860, that the four white men struck through the northern wilderness. They were soon troubled by warlike tribes of blackfellows, but on each occasion they managed to frighten the savages off without hurt. The explorers were now on the unknown western edge of Queensland, and found the country fairly well grassed and watered. Meeting more savage tribes, Burke won them over with gifts. It was quite a pleasant excursion; the party was well fed and in good health; and on February 9, 1861, Burke and Wills went on ahead, walking down the Flinders River, and reached the salt swamp on the Gulf of Carpentaria. The great object of the mission was accomplished, and

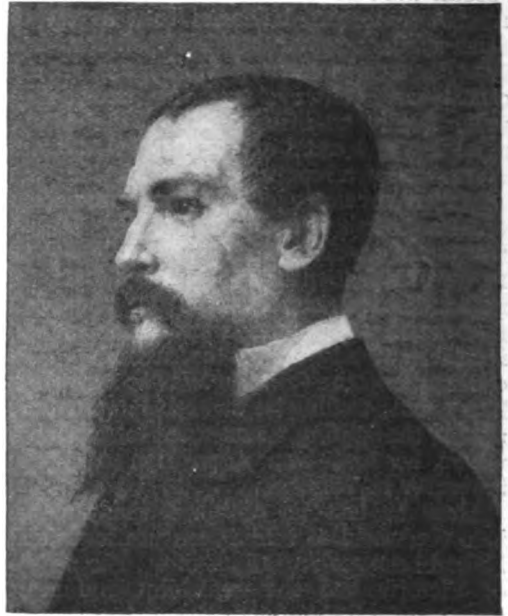
the Australian continent was completely crossed from south to north.

By this time, however, the stock of provisions was sadly reduced, and on February 13 the four men started homeward on short rations. It rained continually, and the mud was so deep that for a time the party could only travel four or five miles a day. So the journey was lengthened and the food supply terribly shortened. Grey first began to feel ill, and four days before the party reached the depot at Cooper's Creek he died. The survivors were so weak that it took them a whole day to dig his grave. This delay proved fatal, for when they arrived at the depot at Cooper's Creek the rest of the expedition had started back seven

ROBERT O'HARA BURKE

hours before. Wright, the cattleman, had not brought up the supplies from the chief depot, and illness and shortage of food had compelled the waiting party to go back. Burke and Willis and King crawled after them; all their food gave out, and their last hope was to find a friendly tribe of blackfellows.

Wills fell first, dying while Burke and King vainly sought for food for him. Burke could only drag himself two miles further, and on the night of June 28, 1861, he expired, with King sitting beside him. Two days afterwards King discovered a store of native food, and ate it, and made friends with the blackfellows by curing one of their women. He lived with the tribe until the rescue expedition found him.

SIR RICHARD BURTON
An Adventurer in Eastern Lands

Sir Richard Francis Burton was an Elizabethan adventurer born two centuries and a half out of time. Fate, that brought him into the world on March 19, 1821, at Barham House, in Hertfordshire, prevented him from shining beside Raleigh and his true peers. The son of an Irishman and a lady of the Highland stock, Burton looked like a gipsy, and led a wildly adventurous and wandering life. Educated in France and Italy, he there acquired the beginnings of his mastery of languages and his passion for travel. An attempt was made to tame him by sending him to Oxford, but when a fellow-student chaffed him about his personal

SIR RICHARD BURTON

appearance Burton flared up and wanted to fight a duel. Modern England was too quiet a place for him in his twenty-first year, and he found an outlet for his energies in India, where, for some years, he wandered about Scinde, picking up native tongues and native ways. At last even the Indian Pathans often could not penetrate his disguise when he dressed as one of them and mingled with them. All this masquerading of Burton had purpose and meaning behind it.

By 1853 he felt sufficiently sure of himself to lay before the Royal Geographical Society a proposal to go to Arabia as an Indian Mohammedan, and fill up the big, blank white spaces on the maps of that country. The scheme was approved, and,

dressed as an Indian Pathan, Burton set off like an ordinary native bound on a pilgrimage to Mecca. On landing on the Arabian coast, he marched through a desolate country to Medina, and then joined a large caravan of pilgrims, and travelled for twelve days through a wild volcanic country unknown to Europeans. Burton carried no arms, and when he chanced to make some little mistake in manners or etiquette he saved himself by his presence of mind and cool courage. But, as a rule, the strange Indian Pathan was forgiven any little eccentricity, by reason of the remoteness of his country from the birthplace of Mohammedanism. He was stopped, however, from exploring Central Arabia by an outbreak of war among the tribes. He had to be content with winning the sanctity attaching to the true believer who makes a pilgrimage to Mecca.

On returning to India, the last of the great adventurers looked for new regions of perilous exploration. At that time the capital of Somaliland, Harar, was exercising over the imagination of Europeans a poetic fascination such as attached to Llassa in our days. An air of mystery and danger enveloped it, and Burton resolved to dispel the mystery. The Government approved his plan, and on October, 1854, he left Aden, disguised as an Arab merchant, and went in search of Harar, the mysterious. After penetrating a vast and populous region scarcely known to geographers, Burton reached his goal, and then returned to Arabia in February for stores to help him on a second and longer journey. But this he never carried out, for, joining Speke, he resolved to ascertain the truth of certain rumours that constantly reached him of a vast sea lying in the heart of Africa.

Early in 1856 the two young explorers left Zanzibar and plunged into the tropical African jungle. They were both stricken with the malaria of the river valleys, but pushed on till they reached a cool and pleasant land of mountains, where they recovered their strength. Farther on, Burton was stricken with a peculiar paralysis, the effects of which lasted over a year. But, on running ahead of the caravan to reprove a native guide, he saw before his eyes, on February 13, 1858, the shining waters of Lake Tanganyika. Then, while Burton was still ill, Speke, acting on information given him by his companion, pushed on and discovered Victoria Nyanza. Burton returned to Zanzibar in a hammock, and on March 22, 1859, he turned home.

But three years later he was lost to view on the opposite side of Africa, busy exploring

BURKE AND WILLS LOST IN THE AUSTRALIAN DESERT
From the painting by John Longstaff, in the possession of the Government of New South Wales.

Benin and Dahomey; and before he arrived at middle age he compressed into his life, as Lord Derby said, more of study, more of hardship, and more of successful enterprise and adventure than would have sufficed to fill up the existence of half a dozen ordinary men.

But in 1861 he entered the employ of the Foreign Office, and served as consul in different parts of the world until his death, at Trieste, October 20, 1890. Many books by him record the strange adventures of his life. "The Pilgrimage to Al-Medinah and Meccah" is perhaps the best from a literary point of view. But his "Lake Regions of Equatorial Africa," published in 1860, is his greatest contribution to geographical science. Excellent also, and full of exciting romance, is his "First Footsteps in East Africa," an account of his visit to the Somali capital, that no white man had entered before him.

JOHN CABOT

The First Voyager to the American Mainland

John Cabot, the discoverer of the American mainland, seems to have been, like Columbus, a Genoese, his true name being Giovanni Cabotto. He was naturalised at Venice in 1476, where his son Sebastiano was probably born in 1474. He again migrated, and in 1490 settled with his family at Bristol, where he became a wealthy merchant. When the news came, in 1493, that Columbus had discovered India, Cabot inquired into the matter, and came to the conclusion that his fellow-townsman had not done so. It seemed to him that Columbus had only struck some unimportant islands on the road to India, and he reckoned that if he set out on a more northerly course he would reach that island of wonders Cipango, which, according to rumour, was the treasure-house of the world, where the palaces of the princes were as richly furnished as Solomon's temple. Such was the European idea of Japan at the close of the fifteenth century.

Cabot went to London, and explained his plan to Henry VII., pointing out that by sailing in a straight western course from England he could reach the eastern coast of Asia by a shorter route than that taken by Columbus. The first and most economical of the Tudors generously granted Cabot, on March 5, 1496, a charter, by which the Bristol merchant was allowed to equip a ship at his own charges, and hand over to the King a large share of all the profits of the discovery; and in the spring of 1497 Cabot set sail from Bristol with two small ships, and landed on June 24, as he thought, in China, and planted the flags of England and Venice there. Whether he struck Newfoundland or the isle of Cape Breton is uncertain, but there are grounds for supposing that he touched at Labrador, and found some snares laid by hunting tribes, who concealed themselves from him. Columbus had only touched the islands of the West Indies; Cabot was the first to reach America. As a reward for the actual discovery of the New World, Cabot received from the King of England the sum of £10! New empires were very cheap in those days. Cabot, however, seems to have drawn great profit from the cod fisheries he found off Newfoundland. He entered into partnership with some Englishmen, who gave up the Iceland fishing grounds, and held for some time the monopoly of the Great Banks.

Cabot was still certain that he had only to follow the coast of the American mainland in order to arrive opposite to Japan, "where all the spices of the world grow, and where there are also gems." As the king would not advance any money, the explorer combined with the merchants of Bristol to fit out and provision five ships for a second voyage to what he fancied was the Far East. It used to be thought that Sebastiano Cabot, the son, was the leader of the second expedition, but a recent authority on the subject, Harrisse, thinks that John Cabot, the father, again commanded the ships, and that the son, after his death, wrongfully assumed the credit of the important discoveries that were made.

In 1498 the little fleet from Bristol was among the icebergs of the Northern Atlantic. Then, turning south to avoid the ice, Cabot again passed Newfoundland and coasted along Labrador as far north probably as Hudson Strait. He found a people wearing the skins of animals, and living in a very barren country, in which there were many white bears and deer as large as horses. Appalled by the desolation and the dangerous ice, Cabot turned his fleet southward, and sought as far as Florida for a passage to China and the Indies.

Weise, the author of "The Discoveries of America," contends that this part of Cabot's voyage is a pure legend, but Spanish writers, though having good reason to belittle the results of the Bristol expedition, are agreed that Cabot led his fleet down to the north of Cuba. The American Polar explorer General Greely, in his "Handbook of Polar Discoveries," also

ON THE WAY TO MOHAMMED'S SHRINE

A GENERAL VIEW OF EL MEDINAH, SHOWING THE CITY WALLS

BURTON IN DISGUISE

A SQUARE IN THE TOWN OF JEDDAH

MOHAMMED'S PLACE OF PRAYER IN THE HOLY CITY OF MEDINAH

credits Cabot with exploring the American mainland from the mouth of Hudson Strait to Florida. He says the voyage "resulted in the knowledge of some 1800 miles of American sea-coast, and, while disclosing the existence of a great continent as an insuperable barrier to voyagers of China, it incidentally gave such an accurate knowledge of America as led to unexpected advantages in later voyages, enabling explorers to have more specific aims and definite destination."

John Cabot died soon after his second voyage, and Sebastiano entered the service of Ferdinand V. of Spain. On behalf of the Spanish Government he examined, in 1526, the coast of Brazil and the Plate River. But he was imprisoned, and then banished, for failing in an attempt to plant a colony; and in 1554 he returned to England and taught the boy king, Edward VI., the variations of the magnetic compass, and was appointed inspector of the English Navy. He was one of the promoters of the English expedition that tried to find a passage to China, around the coasts of Scandinavia and Russia. He died in London in the year 1557.

PHILIP CARTERET

An Explorer of the South Pacific

Philip Carteret, rear admiral, a discoverer of the South Sea Islands, emerges into the light of history as a lieutenant of the "Dolphin," that sailed round the world under Byron in 1764. Byron, the grandfather of the famous poet, had served under Anson, been wrecked in the Straits of Magellan, and was taken prisoner by the Spaniards and imprisoned for three years in Chili. He escaped on a Breton ship, that took him back to Europe. After further distinguishing himself in the war with France, he received the command of two ships from the Admiralty—one being the "Dolphin," on which we first find Philip Carteret, of whose early life nothing seems to be known. The vessels sailed from Plymouth on July 3, 1764, and everybody on board except Byron thought they were bound for the Indies. But off Rio de Janeiro the leader assembled his men and read to them the secret instructions given him by the Admiralty.

"Nothing," ran the Admiralty instructions, "contributes more to the glory of this nation than the discovery of new regions. As there is every reason for believing in the existence of lands and islands in great numbers between the Cape of Good Hope and the Straits of Magellan, situated in latitudes suitable for navigation and in climates productive of marketable commodities, his Majesty, conceiving the existing state of profound peace especially suitable for such an undertaking, has decided to put it into execution." The crews were promised double pay, with future advancements and enjoyments, if the Lords of the Admiralty were pleased with their services. Naturally the sailors cheered when the paper was read to them, and not only at the prospect of adventure and personal gain. It was the age of Chatham, the greatest and the most far-sighted of our empire-builders, and his spirit animated this band of explorers, the first Englishmen to sail the South Seas with this definite object of finding lands for colonisation.

The "Dolphin" anchored in the Downs on May 9, 1766, after the most fortunate of all the circumnavigation voyages undertaken by our nation, but the scientific results were not of much importance, as Byron only discovered a few new islands in the South Seas, and no men of science were sent with him to make special geographical observations. But the Government was resolved to carry out the entire plan they had conceived. Six weeks after the "Dolphin" anchored in the Downs, Captain Samuel Wallis, an officer of the Marines, who had distinguished himself in land warfare in Canada, was entrusted with the command of a new expedition, and Carteret accompanied him in charge of a sloop, the "Swallow."

Carteret came to the conclusion that he and his men were going to their death, for the "Swallow" had been thirty years in service, her sheathing was worn away, and she was quite unseaworthy. He pointed matters out to Wallis, but the marine told the sailor to obey Admiralty orders; and with inadequate provisions and leaking timbers the "Swallow" sailed with the "Dolphin" from England on August 22, 1766. While clearing the Straits of Magellan, Carteret was separated from Wallis by a fog, and as the leader of the expedition had omitted to appoint any rendezvous, there was nothing for Carteret but to turn back to England. His ill-found sloop had been battered by the stormy seas into a state of utter dilapidation, the mizen-mast was broken in the Pacific by a furious tempest, and the ship was very near to foundering. But Carteret had his orders; he did not reason about them, but proceeded to carry them out. So while Wallis circumnavigated the globe by keeping to the known route of earlier mariners, and making no discovery of

importance, Cateret, profiting by his experience under Byron, resolved to die in the work of real exploration.

Steering in a fog by Easter Island without seeing it, he made his first geographical discovery of Pitcairn Island, which was some years afterwards occupied by the mutineers of the "Bounty." Nine days after, on July 11, 1767, Carteret discovered Osnaburg Island, which he so named in honour of the Duke of York. Two more islands were found the next day, but the sailors who landed in search of food and water came back with empty hands. The position of Carteret and his men was now terrible. Nearly all the provisions were consumed or tainted, half the crew was sick, the sloop was badly leaking, and the leak could not be stopped. By unsuspected good fortune, land was sighted on the morrow, and the explorers, in Carteret's own phrase, felt like criminals who had received a reprieve on the scaffold. A hurried landing was made in search of water. At the sight of them the black, woolly-haired natives fled, and a stream was found near the shore. But the next landing-party that went to trade for fresh fruit and food was attacked; three were killed, and others wounded. The young commander, lying sick with fever in his cabin, gave orders for his ship to sail away as soon as the carpenter, now the only healthy man on board, managed to stop the leak in a partial manner.

Several groups of new islands were discovered and charted, but no provisions could be obtained from the natives. It was not till August 20 that a little, low island was found, where cocoanuts were procured. Sailing through an unknown sea, where new lands were encountered almost every day, Carteret reached the coast of New Britain on August 28, and stopped at various bays, where he obtained water and food and fruit. He also repaired his ship, with the intention of finding a fertile island as headquarters for the exploration of the South Seas, and then striking south to the Antarctic before returning to England. Had this been possible, he would have anticipated the chief discoveries of Captain Cook. Unfortunately, the carpenter found the bottom timbers of the ship were badly decayed, the keel having completely gone. It was doubtful if the timbers would hold together for a few months. So Carteret, still wasted and feeble with illness, turned his vessel northward, discovered New Ireland and the Strait of St. George on his way, and reached Macassar, then the principal colony of the Dutch in the Celebes Islands. The Dutch refused to sell provisions for his dying crew, and threatened to attack him if he tried to land.

Going on to a bay in the neighbourhood, Carteret found some kindlier Dutchmen, who sold him provisions at only a thousand per cent. above the proper price. He refitted his ship, but as most of his crew were dead or too weak to work he had to collect slowly some more English adventurers to help him sail the "Swallow." These he did not obtain until he came to Batavia; and from there, on September 15, 1768, he set off for the Cape. A stay in this port enabled his crew to recover their strength, and, after a voyage of thirty-one months, his crazy ship was at last safely anchored in Spithead. While Wallis made scarcely any discoveries of importance, as he kept to the route taken by many sailors before him, Carteret won a position among the greatest geographical discoverers of his age. He retired in 1794, with the rank of rear-admiral, and died at Southampton on July 21, 1796.

JACQUES CARTIER

Explorer and Coloniser of Canada

Jacques Cartier, the discoverer of Canada, was born at St. Malo, in Brittany, in December, 1491. Little is known about his early life, but, like many other sailors of the Breton seaport, he seems to have gone to the Banks of Newfoundland fishing for cod. At the age of forty-two he was famous as the most experienced of French pilots in the North Atlantic, and through Admiral Philippe de Chabot he was able to lay before the French king, Francis I., a proposal for the discovery of the North-West Passage to the Indies. Francis I. was already chafing at the success of the Spaniards and Portuguese in the New World, and he was delighted with Cartier's enterprise. The Breton sailor was given the command of two small ships, and, leaving St. Malo on April 20, 1534, he caught a fair wind that carried him to Newfoundland in twenty days.

After exploring the coast of the island, he passed through the Strait of Belle Isle, and, landing on the coast of Labrador, planted a cross there, and took possession of the territory in the name of King Francis. Blown by a storm across the Gulf of St. Lawrence, he entered Chaleur Bay, and then sailed to the Bay of Gaspé, which he took for the mouth of a great river. After annexing this part of Canada, he turned down the St. Lawrence River,

establishing friendly relations with the Red Indian tribes, and taking with him two sons of chiefs and one of the chiefs.

Cartier, however, was not aware that he had discovered one of the greatest rivers of America. Thinking it was only another bay, he turned his ship towards Europe, and arrived at St. Malo on September 5, 1534, after six months of absence. The ease and rapidity with which he accomplished the discovery of Canada greatly pleased King Francis, and he put at the command of the now famous Breton three ships of the Royal fleet—"La Grande Hermine," of 120 tons; "La Petite Hermine," of 60 tons; and "L'Emerillon," a still smaller vessel—and sent him forth on a second voyage to Canada. On July 31, 1535, Cartier passed down the passage between the island of Anticosti and reached the Saguenay. Farther down the St. Lawrence he turned up another river, and came to Stadacone, an Iroquois village, close to which he passed the winter in a rude fort, mounted with cannon and encircled with a palisade.

JACQUES CARTIER

Before the ice set in, he explored the St. Lawrence as far as a green hill that he named Mont-Royal, which is now the city of Montreal. He then returned to Canada—a word which merely signifies a town, and which he applied to the Iroquois village near which he had built his fort. From November to March the Frenchmen suffered from the rigour of the climate; their ships were frozen in deep ice, and scurvy broke out and killed twenty-five of the crew. But the friendly natives showed Cartier a tree whose leaves and bark made a drink that quickly cured the men who remained alive. When Cartier, however, started back to France he had not sufficient men left to work his three ships, so he abandoned "La Petite Hermine"; and in 1848 broken timbers were dug out of the river mud at the spot where the Breton navigator had left her.

Cartier arrived at St. Malo on July 16, 1536, but when he put his plan for the colonisation of Canada before Francis I. he found that monarch had changed his mind. The king had said, on Cartier's first voyage, that he would like to see the clause in Adam's will which disinherited him of the New World in favour of the kings of Spain and Portugal, but now he was unmoved by the Breton sailor's impassioned account of the fertility and richness of the soil of the new country. Francis wanted gold-mines in the New World, and not a splendid, invigorating land where his people could expand. But a gentleman of Picardy, the Sire de Roberval, was greatly excited by Cartier's description of the new country. By repeated efforts he obtained the king's consent for the colonisation of Canada, and fitted out five ships for the purpose. Cartier went as the pilot of the expedition, and set off with two of the vessels, on the understanding that Roberval would follow him immediately with three shiploads of settlers.

In August, 1541, Cartier sailed by the site of Quebec, and anchored at Cap Rouge, that seemed to him to be the best place for planting a colony. While waiting for Roberval he explored the river as far as the rapids, but on returning he was dismayed to find that the colonists and their leader had not arrived. He stayed till he was caught in the ice, and at the end of the following spring he set out for France, in angry determination to abandon Canada. At St. John's, Newfoundland, he at last met Roberval with three vessels and two hundred colonists, but Cartier held to his course, and sailed back to St. Malo. He was of opinion that Roberval was not the kind of man who could plant and develop a colony. And so it proved. The scheme was wrecked by disease, mismanagement, and discords long before Cartier died in Brittany on September 1, 1557.

FRANCIS RAWDON CHESNEY

Father of the Suez Canal

Francis Rawdon Chesney, the explorer of the Euphrates and the overland route to India, came of a Scottish stock settled in the North of Ireland; he was born at Annalong, in co. Down, on March 16, 1789. At the age of sixteen he joined the Royal Artillery at Woolwich.

Chesney's love of adventure seemed doomed to disappointment. He tried to assist the Turks in their war against Russia in 1829, but the Peace of Adrianople prevented him from seeing any fighting. To pass his time away, he travelled through Egypt and Syria, and looked at the site of the Suez Canal. In a historic report he proved that the conclusions of Napoleon's surveyors were wrong, and that from an engineering point of view the undertaking was perfectly feasible. De Lesseps openly and frankly admitted that it was on the strength of his belief in Chesney's report that he attempted the great enterprise of digging the canal.

On his Eastern travels Chesney also, in 1831, explored the valley of the Euphrates, and pointed out that a new route to India could be made along an old and forgotten road from Syria, leading to the bank of the great river, down which steamers could go to the Persian Gulf. He made his observations on a raft, from which he worked with a sounding-pole. He was often attacked by the Arabs, but at last won their friendship, and prolonged his exploration of the overland route through Persia to Trebizond. He then returned overland to Aleppo by a wilder and more dangerous way, and came to England to agitate for the establishment of the overland route to India.

It took him two years to get a Parliamentary committee appointed to examine into the proposal, but at last £20,000 was voted for a surveying expedition under Chesney. He landed at Antioch, with a troop of artillerymen, engineers, sappers, and miners, and transported in sections two steamers, which his soldiers put together on the upper Euphrates. One of the steamers was sunk, but the other reached the mouth of the great river, thus proving that the Euphrates was navigable to within 120 miles of the Mediterranean. The main work of the expedition was accomplished, but Chesney returned to Mesopotamia to complete his survey of the Tigris.

CHESNEY DESCENDING THE EUPHRATES ON A RAFT IN 1830

With the exception of some years spent on active service in China, the rest of the long life of the man whom De Lesseps called "the father of the Suez Canal" was vainly given in a series of attempts to get a railway from Antioch to the upper Euphrates. He found men ready to build the line, and obtained concessions from Turkey. But Lord Palmerston would not act in the matter, for fear of offending the French, who claimed special influence in Syria.

On January 30, 1872, General Chesney died, a sorely disappointed man.

CHRISTOPHER COLUMBUS
The Man who Found the New World

Cristoforo Colombo, better known to us under the Anglo-Latin form of his name, Christopher Columbus, seems to have been born in the village of Terrarossa, close to Genoa, about the year 1445. The boy was apprenticed to his father's trade of a wool-comber, and in 1451 the family moved to Genoa, in order to be near the wool market. There appears no ground for the statement, made by one of Columbus's sons, that the discoverer of the New World was educated at Pavia University. Columbus himself says that he went to sea at fourteen, and this is undoubtedly the truth. The boy picked up his remarkable fund

CHRISTOPHER COLUMBUS

of knowledge in a life of extreme hardship and great peril. In peaceful voyages he had to fight against the ferocious Mohammedan pirates of the Barbary coast; in warlike expeditions he served under Christian privateers. He first distinguished himself in cutting out a galley from the port of Tunis, and, under a famous corsair of Genoa, he waylaid four Venetian galleys and attacked them off the Portuguese coast, between Lisbon and Cape St. Vincent. The ship commanded by Columbus engaged with a huge Venetian galley, which his crew set on fire by throwing hand grenades. The flames spread to Columbus's ship, and the two vessels became one blazing mass. The men threw themselves into the sea, and Columbus jumped in with them. Seeing an oar floating near him, he seized it, and, being an expert swimmer, he managed to reach the shore, which was two leagues distant.

By this time Columbus had had more than enough of mere adventure. In the course of his voyages he had reached as far north as Iceland, and he was already inspired with the great idea of his life. It is just possible that he may have heard, in Iceland, rumours of the ancient voyage of the celebrated Viking, Eric the Red, to the world beyond the Atlantic, but, as Columbus could not speak Norwegian, any tradition he may have picked up must have been very vague and uncertain. What he really acted on were the theories of the roundness of the earth, the eastward extent of the continent of Asia, and some sailors' legends of strange timbers from unknown trees, bearing the marks of human handiwork, and picked up far out in the Atlantic Ocean. Had he been able to back his collection of wild fancies and gross misconceptions with the historic evidence of the Icelandic saga, that told of the discovery of a world beyond Greenland, he would have made up his own mind more quickly, and more quickly convinced his Royal patrons of the truth of his idea.

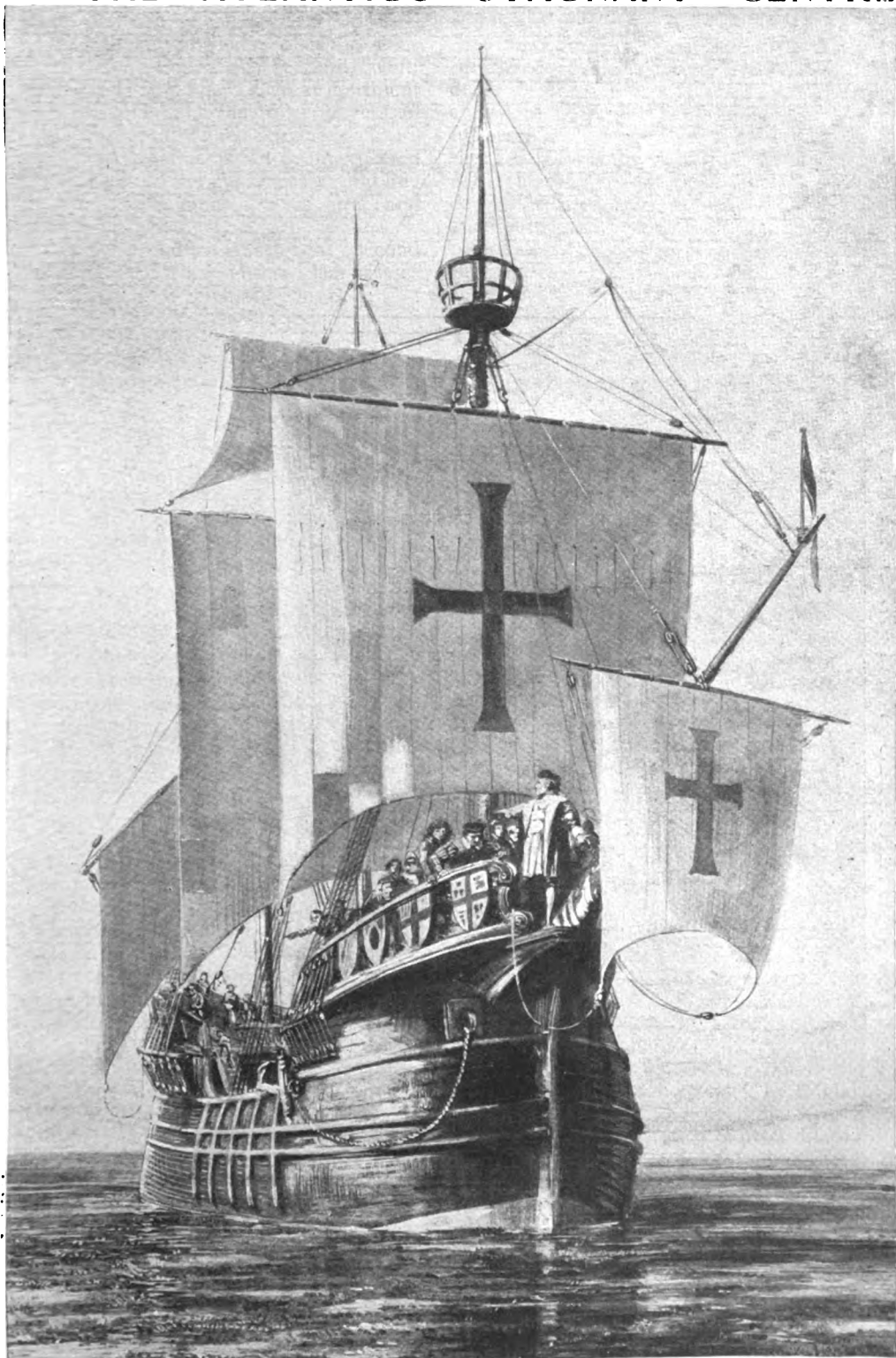
As it was, after his shipwreck, he settled down at Lisbon, and lived by making maps and charts. By marrying a Portuguese lady of rank, who was a cousin of the Archbishop of Lisbon and the daughter of a captain who had become one of the early colonists, and the first governor of Porto Santo, Columbus increased both his position in society and his means of knowledge. He studied the logs and papers of his father-in-law, and talked with the most experienced and the most scientific navigators in the world. All that he read and heard and worked out for himself in map-making convinced him that the greater part of the world was still undiscovered; and, following chiefly the mistaken idea of the length of Asia which he had derived from Marco Polo, he came to the conclusion that India and China were to be reached by a voyage across the Atlantic Ocean.

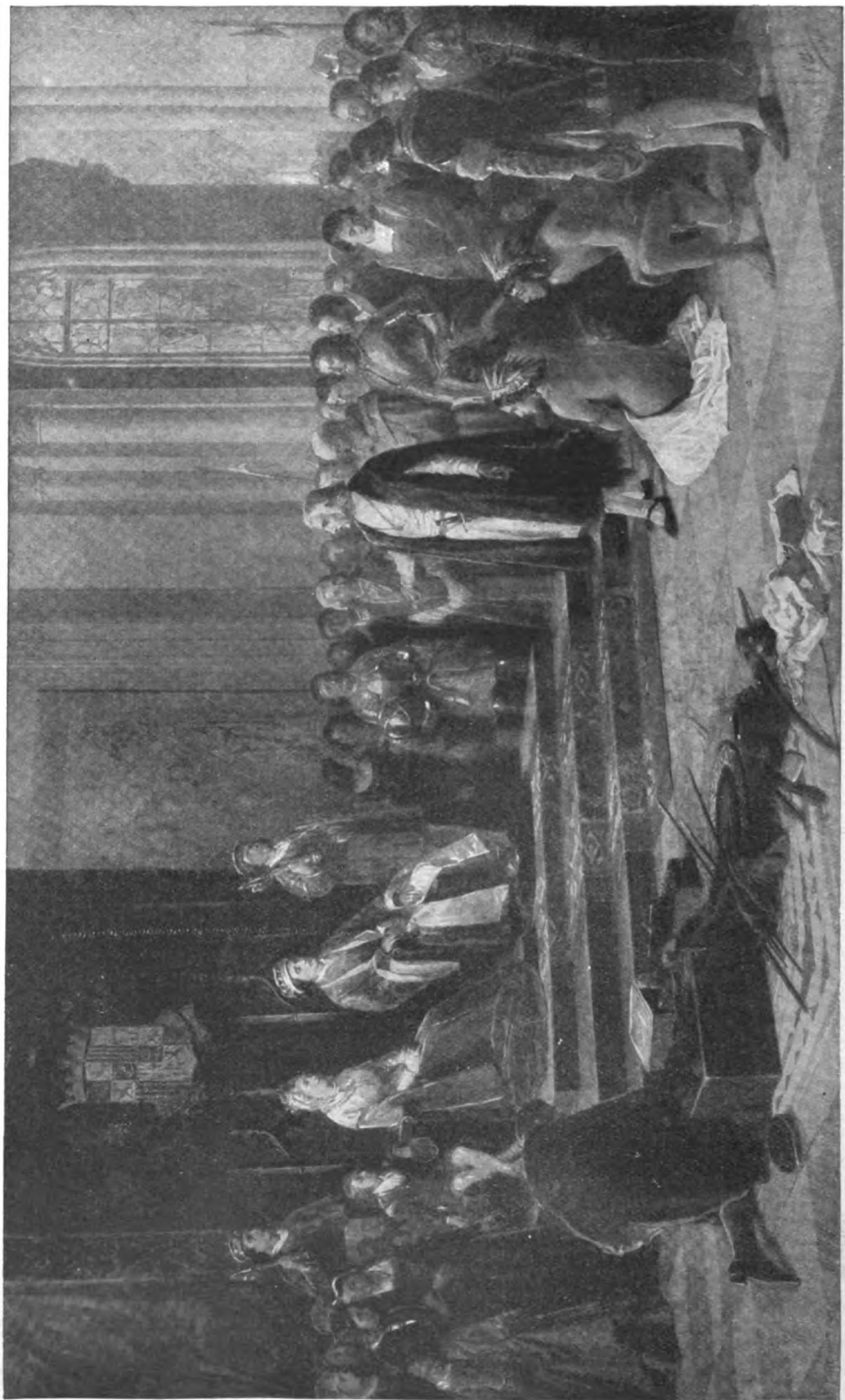
Some years elapsed, however, before he tried to put his ideas into practice. He wanted the aid of a king to bear the cost of the expedition and provide the soldiers for the conquests of the new lands. It was only in Portugal that the passion and science for nautical explorations obtained,

THE WORLD'S MOST HUMANE NAVIGATOR

THE STATUE AT WHITBY TO CAPTAIN COOK, THE GREATEST OF PEACEFUL SEAMEN

FACING PAGE 4527

IN THE ATLANTIC'S STAGNANT CENTRE

COLUMBUS, SEEKING THE NEW WORLD WAS BECALMED IN THE WEEDY WASTES OF THE ATLANTIC

THE GREATEST RECITAL OF ADVENTURES THAT HAS EVER FALLEN TO A TRAVELLER'S LOT

COLUMBUS TELLING THE KING, QUEEN, AND SPANISH COURT HOW HE HAS DISCOVERED THE SECOND HALF OF THE WORLD

but Portugal was at the time at war with Spain, and the king was an unlearned and unenterprising man. It was not until John II. ascended the throne of Portugal that Columbus came forward with his proposal. The new king took up the navigation work of Prince Henry of Portugal, and began to push down the western coast of Africa, with a view to discovering the sea-road to India, and taking the Oriental trade away from the Arabian merchants. Columbus, therefore, had no time to lose if he wished to be the first man to sail to India.

He laid his proposal for an expedition before King John, but some of the councillors appointed to inquire into the matter procured the detailed plan from Columbus, together with the chart by which he intended to shape his course, and told him they would go further into it. This they did by equipping a ship and giving Columbus's plan and charts to some Portuguese pilots, and ordering them to pursue the designated route. The ship sailed westward for several days. But the weather grew stormy, and the Portuguese, seeing nothing but an infinite waste of wild, tumbling waves still extending before them, lost their courage and put back to Lisbon.

This unworthy attempt to defraud him of his enterprise aroused the indignation of Columbus. As his Portuguese wife was now dead, he refused to enter into any further negotiations with King John, and in 1484 he left Portugal in search of a worthier patron. He went to Spain, and, though Isabella of Castille and her husband, Ferdinand of Aragon, were busy with the last great war against the Moors of Grenada, Isabella was struck with the plan of discovery. The matter was submitted to a council of scholars, and for some time they stuck at the notion of the roundness of the earth, which they regarded as contrary to ecclesiastical science. For seven years Columbus was alternately encouraged and repulsed, and at last he despatched his brother to King Henry VII. of England to ask for help in his voyage of discovery. The English king sent for Columbus to learn more about the extraordinary enterprise, but his invitation came too late. Queen Isabella had been at last won over by the eloquence of the tall, lean-faced, noble-looking Italian with fiery eyes that were the windows of a soul flaming with a fanatic courage. In the forty-seventh year of his age Columbus signed a treaty with Ferdinand and Isabella, who, as lords of the open seas, constituted him admiral, viceroy, and governor-general of all islands and continents he should discover in the western ocean, giving him one-tenth of all the products and profits within the limits of his discoveries.

On August 3, 1492, Columbus set sail from Palos harbour with two caravels, or light vessels without decks, and one ship of larger burden, with crews numbering 120 men. For seventy-one days he kept his ships sailing on the western course. His men lost faith and hope long before the voyage ended. Indeed, they were ready after forty-nine days to put their foreign leader to death and turn back home. But Columbus faced his mutinous crew, and inspired them with somewhat of his courage. Land was sighted on October 12, 1492, and is believed to have been Watling's Island, in the Bahamas. Columbus visited Cuba and Hayti, planted a small colony there, and returned to Spain, March 15, 1493, still thinking he had discovered the islands off India.

His second voyage, late in that year, at the head of a fleet of twenty ships, enabled him to sight Dominica, in the West Indies. His third voyage, begun in 1498, resulted in the discovery of the South American mainland. But Ferdinand of Aragon began to see the vast scope of Columbus's discoveries, and regretted having given the foreigner so large a power and so great a share of the profits of the expedition. Queen Isabella was indignant at the well-founded reports that Columbus was enslaving the natives and setting them on forced labour, and a Spanish courtier was sent with high powers to the new lands. He exceeded his instructions, however, by loading Columbus with chains and sending him a prisoner to Spain. The sight of the grey-haired discoverer of the New World walking in irons was more than Ferdinand could bear, and Columbus was restored to favour. In his last great voyage, from 1502 to 1504, he explored the Gulf of Mexico.

He died at Valladolid, in Spain, on May 20, 1506. His conduct in the capture and sale of slaves is a stain on his memory, but otherwise he was an honest, conscientious man of genius, with the mind of a poet and the will of a great leader of men.

CAPTAIN JAMES COOK

Explorer of More Coast Than Any Other Man

James Cook was born at Marton, Cleveland, Yorkshire, on October 28, 1728.

His father was an agricultural labourer, and the boy, who received but scanty schooling, was bound apprentice at thirteen to a haberdasher at Staithes, ten miles from Whitby. The future navigator always heard the call of the sea, and, leaving the shop, was apprenticed to a firm of shipowners who were engaged in the coal trade. The coasting trade, carried on in the roughest seas, has produced many fine sailors, and Cook graduated in an excellent school, trading to London and Dublin, and even as far as the Baltic. In 1752 he was promoted mate, and was in a fair way to settling down as captain of a coasting collier. Three years later, however, to avoid the pressgang, he volunteered for service in the Navy, sailing under Sir Hugh Palliser, who, greatly impressed by the merits of the young man, had his sympathies further stimulated by friends of the sailor's old masters.

During the French-Canadian war, Cook's ship joined the fleet in the St. Lawrence, there to co-operate with the land forces of General Wolfe. Before this could be done, the river had to be surveyed, and the task was committed to Cook, who acquitted himself with credit in the face of considerable danger, once almost losing his life during a concerted attack by a flotilla of native canoes. After the conquest of Quebec, to which his own work contributed, he was appointed to complete his survey of the river, and did his work so thoroughly that his charts served for many years afterwards. His patron, Sir Hugh Palliser, afterwards enabled him to survey the coast of Newfoundland. Cook, in his leisure, diligently studied mathematics and astronomy, was given the command of a ship, and, while in Newfoundland waters, sent home to the Royal Society his observations of the solar eclipse of 1766.

This proved the turning-point of his life, for his careful and admirable surveys, coupled with the scientific knowledge shown in his observation of the eclipse, led to his being appointed to command the expedition to Tahiti, in 1768, to view the transit of Venus, and to navigate the southern seas. The expedition was brilliantly successful in all respects. Cook's preparations were on such a scale as almost to ensure the triumph of his aims. After the transit he sailed south, and circumnavigated the two islands which compose New Zealand, so proving that the long-sought southern continent did not exist in this latitude. He continued his survey along the eastern Australian coast northwards, and took possession of it for Great Britain, the first point touched being named Botany Bay by Sir Joseph Banks, who was of the party.

Over two thousand miles of coast-line were surveyed, and the name New South Wales was given to the whole. In spite of Cook's fine seamanship, the party had a close escape from dire disaster. The ship ran aground, and remained for many hours helpless upon a coral reef. When at last got off, she showed no signs of a leak, the explanation proving to be the singular one that the mass of coral by which the hull had been penetrated had remained as a plug in the timbers of the ship. Cook sailed through the strait between Australia and New Guinea, and, returning by way of Java and the Cape of Good Hope, brought home highly valuable charts of the entire coasts of New Zealand and eastern Australia. He completed his voyage by arriving in England on June 12, 1771.

His experience served still further to stimulate interest in the problem of the South, where a vast unknown continent was still believed to exist. Accordingly, Cook was sent out again on his second great voyage, starting July 13, 1772, to explore the southern seas. It was a magnificent voyage, extending over three years, in the course of which he discovered the New Hebrides, New Caledonia, and other important island groups. The search for the southern land was heroically prosecuted. He could find no great land-stretch reaching from north to south, but he reached the southern ice-cap, and found how far Antarctica reaches north. He sailed completely round the world in this high Antarctic latitude, finally dissipated the belief in the existence of the fabled southern continent, and landed at Plymouth on July 25, 1775.

It is a fact never forgotten in estimating Cook's character that he, the greatest navigator of his age, who had given a continent to England, counted as his chief claim to fame the fact that the precautions he had taken enabled him to carry his crew round the world and home again with a loss, through illness, of only *one* man. That, to his simple, noble nature, constituted his paramount claim to recognition. And it was a great feat, for he was the first man who had ever succeeded in keeping out of his ship that terror of the man of the deep—the fatal scurvy.

His third and last voyage was begun on July 12, 1776, his object being to find

a passage round the north coast of America from the Pacific. He thoroughly explored the North Pacific, discovering on his way thither the Sandwich Islands. He surveyed the west coast of America from 45 degrees north as far as Icy Cape, in Behring Straits, and realised the proximity of Asia and America. Driven back from Icy Cape, Cook made for Hawaii, and put into Karakakooa Bay on January 17, 1779. Here he stayed for some time. The natives, at first friendly, became suspicious and exacting, and resorted to theft. Cook sailed for the open sea, but was driven back in quest of water which he had failed to gain elsewhere. A misunderstanding with the natives arose while he was on shore, and, in a sudden gust of passion, the excitable natives attacked and murdered him at the waterside.

THE DEATH OF CAPTAIN COOK IN THE SANDWICH ISLANDS

He died on February 14, 1779. Part of his mutilated remains were afterwards recovered, and buried with naval honours at sea. On the shore near where he fell grew a tree, the top of which was cut off and brought to England, to be preserved at Greenwich Hospital. The stump, crowned with copper to protect it from disease, was afterwards distinguished by an inscription describing the end of "Captain James Cook, R.N., the renowned circumnavigator, who discovered these islands." Cook's work lived after him. His surveys yielded charts of astounding precision, which, to those that came after, afforded "materials of accurate geography." He explored a greater length of coast-line than any other man who ever lived. He opened the Pacific to human habitation. He revealed the vast archipelagoes which the sluggish Spaniards, during eight generations of domination of this ocean, had failed to discover. He prepared the way for the civilisation of these islands by depositing on them domesticated animals as food, and seeds of fruit and vegetables, which have since borne colossal harvests. He proved that the long-sought southern continent did not exist, but

he showed that the dim, mysterious "New Holland" was in itself a continent, and he gave it to his native land. He remade the map of half the world, and those who followed had but to elaborate and fill in the details. He loved his ship, and he loved his crews. His famous "Endeavour," in which he surveyed the coast of eastern Australia, was only a little collier of 370 tons burden, and yet he thought her the finest ship in the world. None of the day could have done better, but that was largely due to his handling of her, for when she was in narrow ways and treacherous currents he thrust out oars through her ports and rowed her like an ancient galley. Cook married in 1762, and had six children. His widow long outlived all her family, and died, aged ninety-three, in 1835, fifty-six years after the decease of her illustrious and noble-minded husband.

HERNANDO CORTES

HERNANDO CORTES

An Explorer at the Point of the Sword

Hernando Cortes, the explorer and conqueror of Mexico, was born in 1485 at Medellin, in the south-west of Spain. The son of a poor squire, who wished to make a lawyer of him, he spent two years at the University of Salamanca. He quickly learnt Latin and law, and became a graceful writer of Spanish, but his adventurous spirit rebelled at the thought of a provincial lawyer's life. In 1501 he left the university in spite of his father's wish, and, coming home, led so wild a life that the old squire was glad to pack him off to the West Indies, where one of his relatives was Governor of the island of San Domingo. Here Cortes arrived in 1504. He distinguished himself by his bravery in an expedition led by Diego Velazquez, and was rewarded with a grant of land and Indian slaves. He afterwards took part in the capture of Cuba, and received a concession in this island which he exploited so skilfully that he became a rich and ambitious man. Velazquez twice imprisoned him, but Cortes managed to make friends with his old commander, now Governor of Cuba, by marrying his sister.

By this stroke of policy Cortes greatly increased his power, and in 1518 Velazquez gave him permission to fit out an expedition for the exploration of the coast of Mexico. He forbade Cortes to land in the new territory, but by this time Cortes had sunk his fortune in equipping several ships and collecting and arming a host of 660 Spaniards and 250 Indians, with about eighteen horses and ten small brass cannon. Landing in Yucatan, he fought his first battle at Tabasco, and then marched on to the conquest of the mighty empire of Mexico. His men refused to follow him on so mad an adventure against a civilised race that could put hundreds of thousands of soldiers into the field. But Cortes quelled the mutiny by burning his ships, leaving his men no alternative but to conquer or perish in the ghastly human sacrifices that the bloodthirsty Mexicans at that time so largely practised.

How much Cortes knew by rumour of the state of affairs in Mexico is doubtful, but it is likely that he was acquainted with the political conditions of the country, where the Mexicans were in a state of chronic warfare with several neighbouring tribes. The Mexicans themselves regarded Cortes as a divine child of the sun, and when he entered their territory they furnished him with soldiers and guides. The superstition of the divinity of the strange white men even affected Montezuma, their barbaric emperor. He sent ambassadors to Cortes, laden with costly presents, in the hope of inducing the Spaniards to turn back.

The show of wealth, however, only made Cortes more eager for conquest. At Cholula an attempt was made to ambush and kill the Spaniards, but Cortes discovered the plot, and made his name feared by a terrible slaughter. Thereupon the caciques

of the emperor ruling the provinces along the line of march submitted to the Spaniards, and on November 8, 1519, Cortes entered the capital city, and after some days seized the emperor, and, in the presence of the Mexican nobility, put him in irons and compelled him to acknowledge the Emperor Charles V. of Spain as his overlord and pay handsome tribute.

For some months Cortes sent out his men on exploring expeditions, not from any motive of advancing geographical science, but with the aim of consolidating his position and discovering the wealth of the country. He made alliances with all the leading natives who chafed against the Mexican rule, and it is probable that he would have maintained and extended his conquests by craft rather than by slaughter if Velazquez had not interfered. But, jealous of the achievements of his brother-in-law, the Governor of Cuba sent an army of 800 first-rate soldiers against him. Cortes, leaving only 200 men in the capital, marched out and made an unexpected and furious night attack upon the army of Narvaez, the emissary of Velasquez, and captured the whole force. Then, addressing the men sent against him, he so worked upon their imagination by his description of the wealth and glories of the country he had conquered that they joined his little army and marched back with him to Mexico.

Cortes went as swiftly as he could. Alvarado, his lieutenant in the capital, had lost his nerve, and, under the menace of a general revolt, had attacked the Mexicans at one of their festivals, and killed five hundred of their leaders and priests. Naturally the people of the city then rose in fury against the Spaniards, and besieged the palace in which they were quartered. Cortes barely arrived in time to save his men. He had to hew his way through the streets of a city with 300,000 inhabitants. In spite of the fierce and skilled courage of the Spaniards, they were overwhelmed by mere weight of numbers. To save himself, Cortes made Montezuma mount to the top of the palace and counsel his people to leave the Spaniards in peace. There was a moment of silence, then a shout of rage, and Montezuma fell

THE VICTORY OF CORTES OVER THE AZTECS AT OTUMBA

dead, pierced by the javelins thrown at him by his indignant subjects. Cortes was compelled to charge with his men, and hack a way out of the capital. He emerged with a broken army, but, hurrying his men on to the plain of Otumba, he suddenly turned and shattered the large force that pursued him, on July 7, 1520.

This extraordinary victory, won against the great and powerful empire by a little, broken band of Spanish adventurers, brought the princes of the older and more civilised tribes to the help of Cortes. The struggle in the city of Mexico had cost the conqueror 450 Spaniards, most of his artillery, and 4000 Indian allies. But the fact that he had broken the power of the bloodthirsty Mexicans induced 10,000 more Indians to join him when he turned back and laid siege to the capital. It was situated in a great salt lake, and approached by three long causeways with drawbridges.

It seemed impregnable, but Cortes launched nine ships, equipped with cannon, on the lake, sunk the enemy's fleet, and captured a boat containing a nephew of Montezuma who had been made emperor. In the meantime, Cortes also made a series of attacks along the causeway. Although the Mexicans fought with the fury of despair, 50,000 of them perishing during the siege, the city fell when it was almost destroyed, on August 13, 1521. The next year Cortes was formally appointed Governor of New Spain.

After sending out three armies on the conquest of Guatemala, Honduras, and the country to the north, and taking part himself in repressing a rebellion of his own lieutenant in Honduras, he returned to Mexico in 1526, and found that the King of Spain, Charles V., had taken from him the powers of government, and given them to Ponce de Leon. He went to Madrid in 1528, in an attempt to recover the position he had won by the sword, but though he was received with honour by King Charles he could not regain the post of Governor of New Spain. He had to be content with the command of the soldiery.

Poor, and broken in health, he returned to his native country in 1540, and on December 2, 1547, he died in neglect near Seville. Later, his body was taken to Mexico.

VASCO DA GAMA

Who Opened Up the Sea-Route to the East

Vasco da Gama was born at Sines, a small port in the province of Alemtejo, fifty-five miles from Lisbon. Various dates are mentioned between 1460 and 1470, but there is apparently now no hope of fixing the actual year in which the discoverer of the sea-route to India was born. It is a coincidence worth noting that with the fall of the Manchu dynasty in China a new waterway for the ships of the world is being made in the Panama Canal. With the fall of the Mongol dynasty, which preceded the Manchu, a new seaway from West to East had to be provided, and Da Gama was the man to find the track.

There were various reasons necessitating the discovery of this way. Reports reached Europe from travellers overland of a rich and powerful prince in an Eastern domain who ruled all other princes in a land abounding in people and riches. The way that Marco Polo had walked was barred by the rapid spread of Mohammedanism on the one hand, and on the other by the resolute refusal of the Chinese to tolerate intercourse with the Western world. Prince Henry the Navigator therefore made bold attempts to find a way by sea, but left his work incomplete at his death.

Little by little navigators pushed out into the open sea. They sailed farther and farther from their native ports. While the plan for the discovery of a sea-route to India was still debated at the Court of Portugal, and while men were creeping timidly down the West Coast of Africa, Columbus sailed out into the West to reach the East, and found the America which he believed to be the Cathay of Marco Polo's story. It remained, then, for Portugal to seek the promised land by sailing in the opposite direction. Four ships were fitted out by Emanuel I., and the command given to Vasco da Gama. He was of a noble family which for generations had served the Royal Family. Da Gama had distinguished himself in military engagements, and the King appreciated his inflexible will and high courage.

Da Gama sailed on July 9, 1497. It had taken a century to discover that the western coast of Africa ended with the Cape of Good Hope; it would have taken another century to round the Cape had the command of ships lain with men with qualities like those of Da Gama's crews. They proved abjectly craven. At the Cape severe storms were encountered, and the crews, terrified by superstitious horrors incomprehensible in our own day, prayed that they might be permitted to return. Da Gama replied, "I will never go back until I have set foot in India!"

Entreaties failing, mutiny followed, to the end that Da Gama might be killed, and the men themselves left to navigate their way home. But Da Gama was as alert as he was inflexible. He had the mutineers cast into irons, and himself navigated his vessel through the crisis.

The Cape was safely rounded, and the Indian Ocean was entered for the first time since the valiant mariners of ancient days had ploughed its waves in their little galleys. Following the coast-line, the ships found new countries, new cities, new peoples, and at Malindi, on the East African coast, succeeded in gaining the services of expert pilots, who knew their way unerringly across the Indian Ocean. So a course north-east was set, and, ten months from leaving Lisbon, they anchored in the harbour of Calicut, on the coast of Malabar. Here Da Gama set up a marble column to mark his discovery and conquest of India.

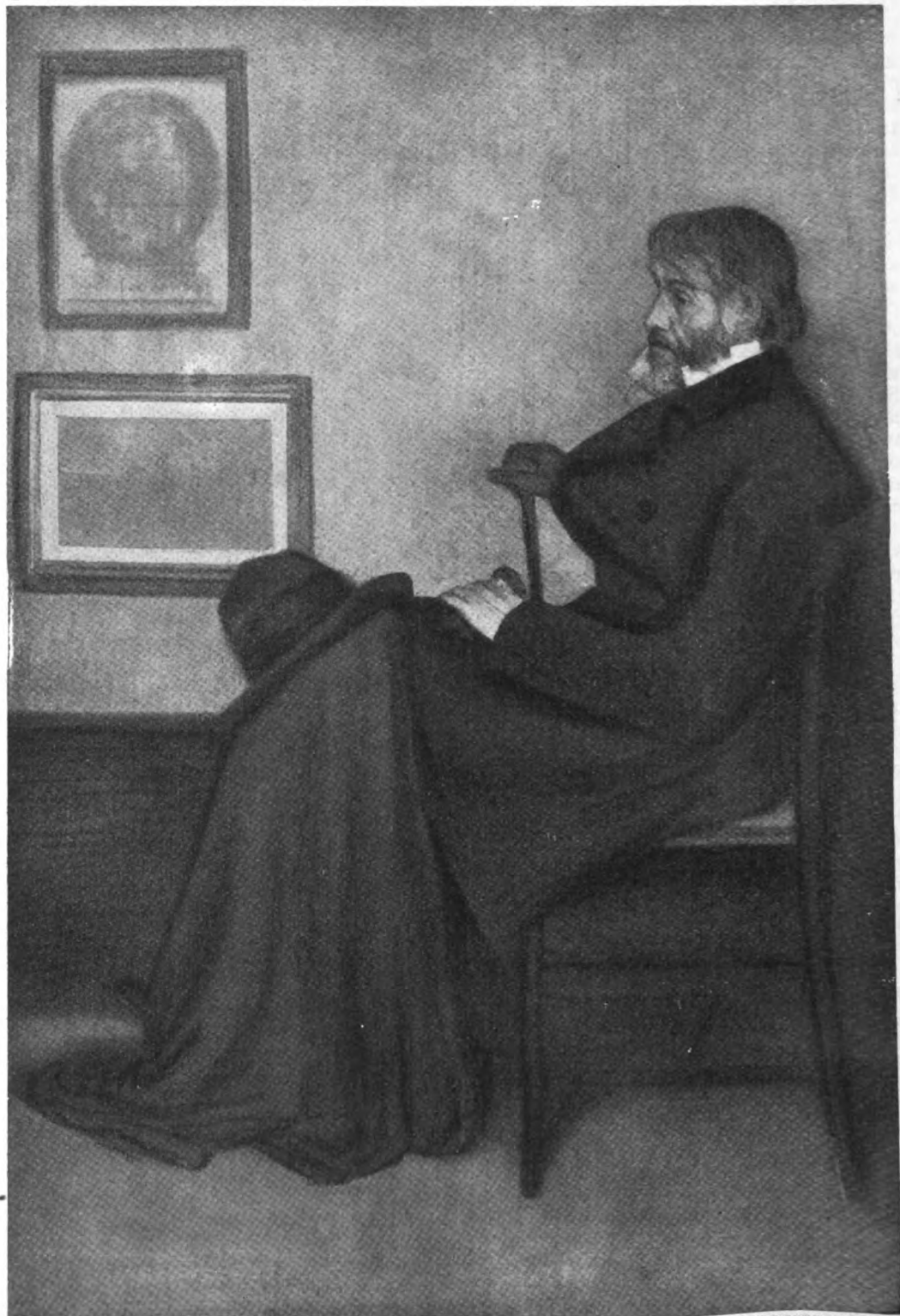
Whatever may have been the feeling of the natives, and of the Hindu ruler who presided over their destinies, the Moorish merchants who were already in peaceful possession of the trade of the country were decidedly opposed to the advance of the new-comers, and stirred up feeling against them. Da Gama plied all his arts as diplomatist, and by gifts and promises did his best to establish a Portuguese settlement, but had in the end to fight his way out of Calicut. He was able, however, to carry back to Lisbon such a report of the wealth and splendours of India as to warrant the King in ennobling and conferring more material benefits upon him. Emanuel immediately despatched Cabral with a powerful fleet of ships to establish a Portuguese factory at Calicut; and it is an interesting commentary on the knowledge of the time that this bold adventurer, on his way to India, did, in fact, discover the coast of Brazil!

However, he fetched Calicut in the end, set up his factory, left forty Portuguese to conduct it, then returned to Europe. The colonists were massacred, and, news of the disaster reaching Lisbon, Da Gama was sent out to avenge the fallen. He exacted a terrible and barbarous retribution, striking not only at Calicut but at many other points. He succeeded in establishing the African colonies of Mozambique and Sofala, and, after carrying his investigations considerably to the east of Calicut, returned to Lisbon with a fleet burdened with spoils.

From that point the real colonisation of the East by the West began. The Portuguese thrust forward their outposts with astonishing energy and rapidity, as well as with atrocious cruelty. Their ships sailed from Lisbon to the farthest point of China, which they still failed to identify as the Cathay of Marco Polo. But abuse followed colonisation, and in 1524 Da Gama was sent out a third time to redress grievances and to punish the wrongdoers.

VASCO DA GAMA

Before he could carry out the excellent plans which he seems to have formed, he was laid low, dying at Cochin on December 24, 1525. His work was of the greatest value to Europe. He wrought a revolution in European trade, made Portugal for the time being one of the richest and most powerful nations in the world, and, still more important, led to the linking of the East and West by permanent ties, to the enrichment of both.

THE EVERLASTING HATER OF SHAMS

THOMAS CARLYLE, AS HE APPEALED TO THE ARTISTIC EYE OF MR. JAMES WHISTLER

THINKERS

GEORGE BERKELEY

The Bishop Who Shook the Foundations of Materialism

George Berkeley, founder of the philosophy of idealism, was born at Dysert Castle, Kilkenny, on March 12, 1685, the son of an officer of Customs. In 1696 he was put to Kilkenny School, and four years afterwards was qualified to matriculate at Trinity College, Dublin. This was at a time when men's minds were agitated by fresh forms of thought. The famous "Essay" of Locke was giving a new turn to speculation. Traditional scholasticism was discredited. Eager students found it difficult to treat with patience the old-fashioned routine of the university.

Berkeley, however, devoted himself with energy to the ordinary work of the college. His career was distinguished. He became scholar in 1702, B.A. in 1704, and Fellow in 1707. Nevertheless, while his original and noble mind thus submitted itself to the established drill of the university, he was following out for himself an entirely new and altogether daring course of speculation. He kept at this time a "Commonplace Book," in which he entered his thoughts, and to which all his biographers have since turned to trace the interest, growth, and progression of his mind. A society, which he helped to form, was founded for the purpose of discussing the new ideas raised by Descartes and Locke. It is quite clear that, while he followed the routine of his duties with entire devotion, Berkeley was fashioning with slow steadiness the new philosophy which his original mind had constructed from the defects of the materialists. In 1707 he published a couple of tracts on mathematics; in 1709, the year in which he was ordained deacon, came his wonderful work entitled "A New Theory of Vision"—the first fruits of his bold originality.

In this book Berkeley contrasted the ideas which rise in the mind from the two senses of sight and touch. He argued that a person born blind, on recovering his sight, would not recognise with his eyes the objects to which he had accustomed himself through touch, and pursued this idea into a region where matter seemed to lose itself in non-existence. During the following year he published the complete statement of his idealistic philosophy under the title "Principles of Human Knowledge," wherein he showed that matter has no existence outside of mind.

To the theory of the materialists, that only from the tangible and visible universe can man receive ideas, Berkeley opposed his bold theory that this tangible and visible universe has no separate basis of existence, and is the symbol of Divine intelligence. Philosophers were speaking with the greatest assurance of substance and matter, were referring men to these things as the limits of human knowledge; Berkeley challenged them for definitions. He brought to scepticism a doubt. He shook the material foundation of materialism. What is substance? What is matter? Men argue about these things, deduce conclusions from them, but do not stop to inquire what exactly these things are.

The practical reader will easily see the difficulties in the way of accepting Berkeley's thesis, but he will find it equally hard to accept the dogmatism of materialism after having pondered Berkeley's idea. A very excellent instance of the world's attitude to this question is given in Boswell's "Life": "After we came out of the church, we stood talking for some time together of Bishop Berkeley's ingenious sophistry to prove the non-existence of matter, and that everything in the universe is merely ideal. I observed that, though we are satisfied his doctrine is not true, it is impossible to refute it. I shall never forget the alacrity with which Johnson answered, striking his foot with mighty force against a large stone, till he rebounded from it—'I refute it *thus*.'" And on another occasion: "Being in company with

a gentleman who thought fit to maintain Dr. Berkeley's ingenious philosophy, that nothing exists but is perceived by some mind; when the gentleman was going away, Johnson said, 'Pray, sir, don't leave us, for we may perhaps forget to think of you, and then you will cease to exist.'"

These "arguments" of the great doctor are not to be considered seriously, but they very fairly represent the attitude of the plain man towards the subtleties of metaphysics. Byron's phrase, "When Bishop Berkeley said, 'there was no matter' . . . 'twas no matter what he said," is familiar enough; and we have long been acquainted with the questions and answers, "What is Matter? Never mind. What is Mind? No matter." Thus will the world always reply to the too nice disquisitions of a philosophy beyond its depths. A later thinker has well pointed out that if we are to question and to define at every step in progress we must not stop at the eye which sees, but go on to the brain which thinks. We have nothing to prove that the human eye presents to us the world as it really is, and nothing to show that the human brain is an instrument for truthful apprehension and conclusive ratiocination. Such speculations lead infallibly to paralysis of the reason and fatalism of the mind. Berkeley's enduring fame was established by his "Principles of Human Knowledge," and on a visit to London he was presented at Court by his famous countryman Jonathan Swift. At this point it is necessary to turn our attention from the philosopher to the man, and to realise the charm and grace of Berkeley, which made him one of the most attractive men of his age. This pleasantness of personality was no mere surface accomplishment. It was rooted in the purest good-nature and the profoundest devotion to religion. Miss Vanhomrigh, the "Vanessa" of Swift, left him half her fortune, having met him only once, and that at the dinner-table of the witty Dean.

BISHOP BERKELEY

Berkeley had travelled to many countries, first as chaplain to Lord Peterborough, and afterwards as tutor to the son of Dr. Ashe. In 1721 he returned to Ireland as chaplain to the Duke of Grafton, and became Preacher and Divinity Lecturer at the University. In the following year he became Dean of Dromore, and in 1724 Dean of Derry. Here, with a large income, and with the comfortable fortune which he had received from Miss Vanhomrigh, it might have been thought that Berkeley would settle down to the careful and satisfactory life of a philosopher. But he was moved by a great religious impulse. He conceived the idea of a mission to the New World to convert the heathen of America to Christianity.

The practical suggestion which he made to the Government was that a college should be established in the Bermudas; he offered to resign his rich deanery and to go out as the head of this college at a salary of £100 a year. It was an exceedingly difficult task to get the Government to listen to his proposal. While he was working to this end, with incredible efforts and unyielding faith, he met the daughter of Judge Forster, proposed marriage to her, and, a month before the Government accepted his suggestion, made her his wife. In 1728 he started for the New World with his wife and a few devoted friends.

The Government had promised £20,000. The party journeyed to Rhode Island and there waited for the Government to fulfil its promise. That promise was broken. For at least three years Sir Robert Walpole kept the missionary hanging on the hope of fulfilment, but finally announced that the promised grant would not be paid till it suited public convenience.

During his years of waiting Berkeley purchased a farm, cultivated a wide acquaintance with the people, and endeared

himself to everybody. Only when he saw the hopelessness of his ambition did he turn back to his native country. The period of waiting for Government aid had been intellectually fruitful, and Berkeley published soon after his return to England (1732) one of his most brilliant pieces of work, "Alciphron; or, the Minute Philosopher," a dialogue which reveals the philosophical inconsistencies of materialism and infidelity. In the following year he was raised to the Bishopric of Cloyne.

Much amusement has been caused by the Bishop's devoted zeal in advertising the merits of tar-water as a cure for disease. To him we owe a phrase usually ascribed to Cowper, who applied it to tea. Tar-water, said Berkeley, is of a nature so mild and benign and proportioned to the human constitution as to "warm without heating, to cheer but not inebriate." He mixed up his advocacy of tar-water with his philosophy.

Bishop Berkeley was a devoted family man, and the death of a son in 1751 was a cruel blow to the old man. In the following year, that he might be near to his second son, who was then at Oxford, the family moved from Ireland. He was something of a physical sufferer at this time of his life, but bore all his pains with exemplary fortitude. On Sunday evening, January 14, 1753, while he was sitting in the midst of his family, he suddenly collapsed and passed away. He was buried in Christ Church, Oxford.

GIORDANO BRUNO
A Martyr of Science who Declared that God is Everywhere

Giordano Bruno was born in 1548, at Nola, near Naples. The inhabitants of this town, which he has made for ever glorious, were probably of Greek origin. He loved his native town, and delighted to call himself a "Nolan." Before he had completed his fifteenth year, young Bruno entered the Dominican monastery in Naples, and there he was an ardent student, notably of Thomas Aquinas, who, three centuries earlier, had lived and taught in the same monastery. But already he was threatened with an accusation of heresy for his freedom of thought; and when he became acquainted with the theories of Copernicus "the mediæval Church's concept of the world dissolved before his eyes like a phantom."

In his twenty-eighth year, being formally accused of heresy, Bruno escaped from Rome, and began a life of constant wandering throughout half of Europe, which continued for more than fifteen years.

THE MONUMENT TO BRUNO IN ROME

Though he was excommunicated, his intellectual powers and inspired speech gained him a hearing in many centres of thought. Thus we find him, in 1583, lecturing in Oxford, where he discoursed on the Copernican astronomy, and made abundant enemies for himself among those in academic authority, as everywhere else, by his conviction and courage of mind. He spent two years in London, however, where he lectured and wrote largely, and where his chief writings were composed.

"There is, in truth," he taught, "only one heaven, one immeasurable space and womb which comprehends all things, one ethereal realm wherein all things circulate. In this universal space shine countless stars, in themselves suns, or rather solar systems, since every star is encircled, like our sun, by planets, or earths. There are but two kinds of heavenly bodies, self-luminous or suns, and illuminated or earths; and the reason why we only see the sun of other systems is the vastness of their distance and the minuteness of their planets. Seen from a little distance, our sun would show merely as a twinkling star."

This, we must realise, is infinitely more than Copernicus had taught. The great astronomer of the North had indeed deposed the earth from its supposed place as the centre of all things, and had stated the essential fact of the solar system. But Bruno's mind took the tremendous step of seeing that the stars must be suns, and that the sun is a star. Now, this is true. As Professor Riehl says, in his admirable monograph upon Bruno, published in celebration of the tercentenary of the crime which killed him, "Bruno's world is, as we now know, the real world. It should never be forgotten that the true constitution of the Cosmos showed itself first to his mind."

He declared the unity of Nature and of the creative power which is everywhere at work in her. He asserted, therefore, the evolution of life on other worlds than ours. God, he said, was everywhere, the basis of Nature—"therefore it is well said that 'in Him we live and move and have our being.'" "We seek God," he said, "in the unchangeable, unalterable laws of Nature; in the disposition of a mind directed reverently towards the law; we seek Him in the light of the sun, in the beauty of all that springs from the bosom of Mother Earth, in the true reflection of His Being in the sight of unnumbered stars which shine on the immeasurable skirts of the one heaven, and live and feel and think and magnify the All-Good, the All-One, the Highest."

Let us now see how this thinker fared. Leaving England, he lectured again in France, and then in Germany. He spoke some time in Frankfort, whence he was lured to Venice, at length, by a young noble, among the most ignoble of men, named Giovanni Mocenigo, a tool of the Inquisition. The unsuspecting Bruno, the philosopher and poet, who called himself "Child of the Sun and of Mother Earth," complied with the invitation to teach this distinguished pupil, who, nine months later, denounced to the Inquisition the teacher who was his guest.

In May and June of 1592 the first trial of Bruno was held. After threats, delay, and probably the rack, at the end of July Bruno recanted. He remained in the prison of the Inquisition in Venice, however, from which he was then transferred to that in Rome. There he remained for years. He did not enter his prison heroically; he first appears as a hero when he leaves it. At last he could rise to the height of his own sublime words, "Whoso still fears for his life has not yet made himself one with the Godhead." Early in 1600, having withdrawn his recantation, he was condemned, and given over to the "secular arm" of the Church, with the usual instruction that he should be "dealt with as gently as might be, and punished without the shedding of blood"—that is to say, he was sentenced to be burnt.

On Friday, February 17, 1600, having finally refused to recant, Bruno was led to the stake in the Campo dei Fiori, or Field of Flowers, in Rome. There he was duly murdered. "And so," writes a distinguished onlooker, "he perished miserably in the flames, and in those other worlds which he imagined he can narrate how the Romans are wont to treat such blasphemous and profligate folk as himself."

There is no authentic portrait of this man, who was killed for first truly stating the nature of the Universe, but we know that he was short, slight, pale, quick of movement, impulsive, fastidious, and temperamentally a poet rather than a student. As Riehl truly says of him, he "was no mere thinker; in life, a poet, a seer, and an apostle; in death, he was a martyr and a hero." He prophesied that no coming century would refuse to bear witness that, like a conqueror, he did not fear death, but, with a steadfastness great as that of any hero, preferred death to an inglorious life.

Time has done him justice. In the fine words of Riehl, translated by Miss Agnes Fry, "Three centuries ago, Bruno died, cursed by the Church and execrated by men. But since 1889 his monument stands on the Campo dei Fiori, on the spot where, in the year 1600, the faggots blazed. But more imperishable than this visible monument is that invisible one raised by Bruno himself in the greatness of his mind and character, which stand before the coming world, a monition and an example."

THOMAS CAMPANELLA

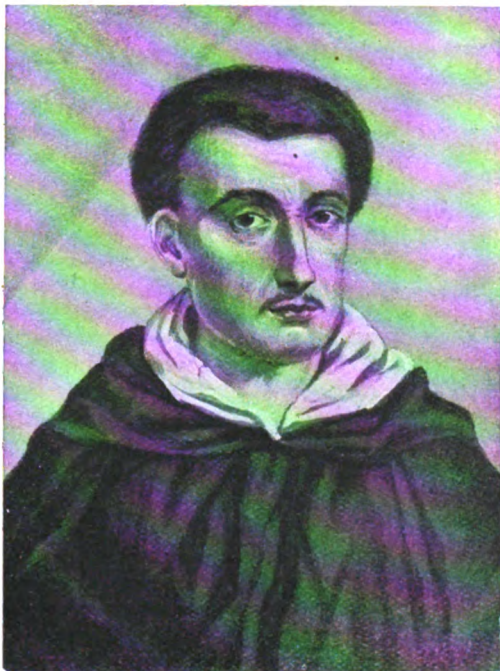
A Rejected Dreamer of Good Government

Thomas Campanella, one of the sufferers for science who dreamed wise dreams in the darkest of ages, was born in Calabria in 1568. In those days the way of education in Italy lay through the Church, and he joined the Dominican Order when quite young, but his eager, inquiring spirit could not be brooked by the Church as it then was. Quite early Campanella revolted from the slavish adherence to what was regarded as unassailable knowledge bequeathed by Aristotle. He urged that each generation should follow Aristotle by doing what Aristotle did—namely, go to Nature for knowledge, and base science on observed fact.

For complicity in a rebellion in his native province against Spanish rule he was captured, and remitted to the Inquisition. Even the interposition of the Pope did not save him from torture, and for seven-and-twenty years he was imprisoned. It was during this period that he wrote the book which has come down to us, and still retains vitality—his picture of an ideal State as "The City of the Sun"—"Civitas Solis."

His enemies continued to pursue him, so finally he escaped to France, where he lived under the protection of the French king, who awarded him a pension, and he died in 1639 in Paris, at the Dominican convent, after over seventy troublous years.

"The City of the Sun" is in the form of a dialogue between a Grand Master of the Knights Hospitallers and a Genoese sea captain, who has seen strange lands, and, prompted by an occasional question, recounts what he found, particularly in one land—Taprobane, a large plain immediately under the equator. After describing the architecture of the city, the traveller tells how it is ruled by three princes of equal might, Power, Wisdom, and Love. To Power belongs the care of all matters relating to war and peace. Wisdom rules all the liberal arts and all the sciences—and of those sciences and arts the book gives a survey. "Love is foremost in attending to the charge of the race. He sees that men and women are so joined together that they bring forth the best offspring." So that even in the "City of the Sun" they knew of eugenics. Though the style is stilted, and the book often a formal parade of the routine virtues, it is lighted by gleams of wisdom that even now are but inadequately appreciated. In the City "both sexes are instructed in all the arts together."

"They consider him the more noble and renowned who has dedicated himself to the study of most arts, and knows how to practise them wisely. Wherefore they

THOMAS CAMPANELLA

laugh at us in that we consider our workmen ignoble, and hold those to be noble who have mastered no pursuit." The "City of the Sun" follows rather closely Plato's "Republic," which obviously is its writer's inspiration. Even the giving of children to the State and not to the parents is imitated from Plato. A reading of this bold monk's thoughts shows how far the world has travelled in pursuit and acquisition of knowledge in three hundred years, but it also shows that in these early days men had well weighed schemes that yet are unrealised.

Campanella, like Aristotle, was wistfully groping after a science never attained,

but the will and the effort and the boldness of the quest in the face of danger deserve lasting honour

THOMAS CARLYLE

The Thinker who Made Ideality Real to Men

Thomas Carlyle, the superlative seer of the great Victorian era—great even beyond the era of Elizabeth—was born on December 4, 1795, in the grey little village of Ecclefechan, Dumfriesshire, the son of sterling Border folks—the best stonemason of the district, and a mother whose descent, as her son said, was from "the pious, the just, and the wise." His education was that of the true Scottish mode—by way of the village school, the local academy (at Annan), and the University of Edinburgh. He came to the University ninety miles on foot when he was not yet fourteen years of age. Before he was nineteen he was back at the school at Annan as a teacher of mathematics. When he was twenty-one he was earning a hundred a year, at Kirkcaldy, still as a teacher of mathematics, and preparing to be a minister. Two years later he had removed to Edinburgh. There he took pupils, thought of becoming an advocate, began writing articles for Brewster's "Edinburgh Encyclopædia," and plunged deeply into the German literature which in a few years so greatly influenced his life.

At Kirkcaldy Carlyle formed a strong friendship with the visionary Edward Irving, who also was from the Annan school, and Irving introduced him to Jane Welsh, a doctor's daughter. Later, for more than two years, Carlyle became a tutor in the Buller family, and with them visited London. In 1824 he gave up tuition, and trusted to literature for a living, writing a "Life of Schiller" for the "London Magazine," before its publication in book form in 1825. He also translated Legendre's "Goemetry" from the French, and Goethe's "Wilhelm Meister," and various romances from the German.

In 1826 (October 17) he married Jane Welsh, and settled for two years in Edinburgh, writing articles for the "Edinburgh" and other reviews. He had been introduced to Jeffrey when in London with the Bullers, and at that period met, and deeply impressed, a number of the literary notabilities of the day. In 1828 he removed to Craigenputtock, his wife's property in Dumfriesshire, and lived there till 1834, in solitude, with occasional visits to Edinburgh and London, and in these years did the most distinctive work of his lifetime. Besides his essays on Burns, Johnson, Goethe, Voltaire, etc., and a history of German literature, he planned his "French Revolution." and completed "Sartor Resartus," which remains his spiritual biography and his literary masterpiece.

During these years, while he found himself, and set his mark on British literature for ever, Carlyle was barely earning a living by his pen. "Sartor Resartus" appeared in "Frazer's Magazine" in 1833–4, but not in book form till 1838, the year after the publication of the "French Revolution." In June, 1834 the last removal was made, to Cheyne Row, Chelsea, and there the Carlyles lived and died—the wife nearly thirty-two years after the arrival in London, the husband nearly forty-seven years. It was a period of gradually growing fame, with all the dread fear of poverty gone from the last forty years.

In the period 1837–40 four popular courses of lectures were delivered in London, the most notable being on "Heroes, Hero-Worship, and the Heroic in History." From this time forward the keenness of Carlyle's strife was ended.

The dates of the publication of Carlyle's remaining principal books must suffice here for an outline of his literary life. The brilliant "French Revolution" (1837) put the seal on his fame; "Chartism," the most democratic of his books, appeared in 1839; "Past and Present" in 1843; "Oliver Cromwell's Life and Letters"—a revelation in historical portraiture—in 1845; the "Life of Sterling" in 1851; and the "Life of Frederick the Great"—a monumental labour—in 1858–65.

The culmination of the author's triumph and the end of his hopes came in the latter year. He was now recognised as the greatest literary individuality in the world. On April 2 he was installed, amid scenes of unbounded admiration, as Lord Rector of Edinburgh University, but the light of his life went out with the sudden death of his brilliantly clever wife on April 21, and only sorrow, merging into bitterness, was left.

Carlyle's "Reminiscences," written during these sad years, were published in the year of his death; and an unpardonably cruel "Life," in two volumes, followed from the pen of his friend and executor, James Anthony Froude, with an equally unwarrantable volume of "Letters and Memorials of Jane Welsh Carlyle." Never were man and wife more foully used in the name of friendship. Carlyle died on February 4, 1881, and was buried with his

fathers in the kirkyard of Ecclefechan in preference to the Abbey.

Considered as a life, Thomas Carlyle's career inflicts upon us a persistent sadness. It was a life of stern struggle, first to secure a full education, then to attain a point of view that was consistent with rigid honesty of thought and unswerving manhood, and all the while to earn the modest living of a simple, intellectual man with tastes that ranged over the world's growth in thought. Success came with a desolating slowness, and when it arrived it was robbed of its natural satisfaction by private and irrecoverable loss; and yet this dour, unsatisfied man has left to mankind a priceless legacy. What is it that will always bring Carlyle back into his own again? The grateful and enthusiastic admiration of all who can be fired by the touch of genius. In his day he was the inspirer of a generation of earnest men. Later, when the defects of his qualities became magnified in Froude's undiscriminating and calumniating biographies, the meaner souls who find a joy in belittling greatness gleefully obscured his true character. But again the message he brought is emerging, and will remain a lasting possession of humanity.

For in Carlyle was enshrined the subtlest spirit of ideality. He preached transcendentalism with a force that surpassed infinitely the propositions of the formal philosophers —a force that was felt like an elemental impulse. To Carlyle matter only exists to represent some spiritual idea. "Heaven and earth are the time-vesture of the Eternal. The Universe is but one vast symbol of God; nay, if thou wilt have it, what is man himself but a symbol of God?" To Carlyle all history is "the mysterious vestiges of Him Whose path is in the great deep of Time, Whom only all History and all Eternity can clearly reveal."

In the long roll of prophets of all nations, none, not even among the rapt seers of the East, has made men feel more profoundly than he the reality of the spiritual life within the material earthly life; and to feel, also, in the presence of that Soul of the world, how great is the sanctity of truthfulness. The real things that matter, because they will endure though heaven and earth pass away, were the things of which Carlyle wrote when he was most himself. "Love not pleasure; love God—this is the Everlasting Yea," was the message he gave to men. That there is a Soul of goodness by which man may abide, and which he cannot forsake without disaster, rang through his writings, and though he formulated no doctrine, and defined no exact faith, he remains the most spiritual of influences in English literature, the most exalting contributor our race has given to the ever-growing Bible of mankind.

WILLIAM KINGDON CLIFFORD
A Genius of Mathematics

William Kingdon Clifford was born at Exeter on May 4, 1845, the son of a bookseller in that town. His mathematical genius early asserted itself, and he was Second Wrangler at Cambridge in 1867. He had been brought up as a High Churchman, but the native bent of his mind was towards

WILLIAM KINGDON CLIFFORD

philosophy as well as mathematics, which is perhaps the most philosophical of the sciences, and before long he began to think and write on independent lines, which brought him into association with such men as Sir Leslie Stephen, Sir Frederick Pollock, John Tyndall, and the evolutionary thinkers of the time.

His contributions to mathematics and scientific theory are very valuable, his "Common Sense of the Exact Sciences," which was completed, after his death, by Professor Karl Pearson, being notable among them. In 1871 he became Professor of Mathematics at University College, London, which had been founded

for the advancement of learning without religious tests or ecclesiastical control. But perhaps the deepest part of the young thinker's mind is found in his "Lectures and Essays," with their brave pessimism and their sincere and moving rejection of the belief in a Deity who had been, in Clifford's words, the "Great Companion."

We do not know whither his mind would ultimately have travelled, for he died at Madeira on March 3, 1879, not having completed his thirty-fourth year, his untimely death being a great loss to mathematics and the advance of human thought.

AUGUSTE COMTE

The Founder of a New Religion

Auguste Comte was born, of Roman Catholic parents, on January 19, 1798, at Montpellier. There and in Paris he was a quick but independent student, mathematics being the most natural interest of his adolescent mind. But already he was unruly under established authority, and he was expelled from the Polytechnic School of Paris as the leading spirit in a scholars' revolt. When he was twenty he came into association with the famous French writer Saint-Simon, one of the truly seminal minds of our modern social theories. For six years Comte learnt from and with the elder man, and then they quarrelled.

Soon afterwards Comte began to lecture and write upon his own system of thought, which ultimately took form in the six substantial volumes of his great work, the "Positive Philosophy." The latter years of his life were monetarily supported by John Stuart Mill, his chief follower in this country, and by a few others who valued the great Frenchman's thought.

Comte's chief and central theory was that of the "three stages" of human thought. The first was theological, wherein the "gods"—or "devils," for the matter of that—were regarded as the capricious and irresponsible movers and causers of events. The second, he said, was the metaphysical, in which the "gods" were deposed, but abstractions like Fate, or Necessity, or still subtler ideas, were asserted to be the causes of things. Finally, there came the third stage, which Comte called *positive*. All superstitions, all abstract ideas, everything other than positive, empirical knowledge, gained by direct experience, was now banished, and man's life must therefore be based upon "hard facts," and those alone.

Hence the new Religion of Humanity, or Positivism, which Comte invented. This was a partly logical, partly emotional development from his scientific and philosophical ideas. Comte was a genuine philosopher, beyond a doubt. The world was all one, for him; and progress, on the lines he laid down in his law of the three stages, was a fact. The various sciences led into and up to one another, beginning with the inorganic, on to the organic, and thence to the super-organic, by which latter he meant the sciences of the human mind and its consequences. The chief of these consequences is the growth and development of civilisation and society. Law and order were to be found here also, Comte declared, as in the realms of geology or chemistry. Hence he invented the word *sociology*, now familiar, to indicate the science of society, based upon all the simpler sciences, and necessary to be cultivated in the best interests of mankind.

Positivism, of which the chief living disciple is now Mr. Frederic Harrison, was to recognise, cultivate, and use all these sciences, culminating in sociology and practical ethics, for the service of mankind. Like all great thinkers in all ages, Comte realised the essential unity of mankind, and of the human enterprise in time, as well as in space. The totality of worthy human life, past, present, and to come, was the object, and the sole object, of worship in this Religion of Humanity—the "Great Being," as Comte called the sum of the best life of our species.

The coldness and lack of personality which such a religion must possess, while it remains a mere summing up of a philosophical conception, are partly got rid of by the formation of a calendar, not of saints, but of great men who have contributed notably to the advancement of human progress, and to the elevation of human character. If the sum total of human life is what is commonly spoken of as God, and our highest and dearest aim should be to serve this aggregate Humanity, which becomes more purified as the ages pass, then the best individual thing we can know is the life of a good and great man who spent himself for the best human causes. In such men humanity reached most perfect fruition; and, acknowledging this, Positivism draws up its historical list of servants of the Common Cause, and commemorates their anniversaries with something of religious fervour. In this way it seeks to satisfy and use the sense of gratitude that all thoughtful men must feel as they contemplate the work of the Platos, Pauls, Brunos,

Newtons, and other "mighty dead who rule us from their urns."

In 1845 Comte, who had contracted an injudicious marriage in 1825, made the acquaintance of a very remarkable woman, Clothilde de Vaux, who had a deep and significant influence upon his thought. He became less hard, less dogmatic, much more alive to the *less* "positive" and perhaps profounder things of life. Much of the more beautiful part of Positivism is clearly due to her influence. His "System of Positive Polity," the chief work of his later life, is a notable instance of this, and may be commended to the reader, either in full or in one of the English abstracts.

Comte died on September 5, 1857, and was buried in the cemetery of Père-la-Chaise, in Paris, among so many of the illustrious dead of his race. Positivism has not gained the success which he anticipated for it, but many of Comte's ideas have borne much fruit in Mill and Spencer, and in modern sociology through their influence. For his extension of the idea of law to the most complicated phenomena of human life, and for his unswerving devotion to the ennoblement of that life, his name will always be honoured in the history of Humanity, the "Great Being" whom he worshipped.

CONDILLAC

The Senses as the Only Avenue of Knowledge

Etienne Bonnot de Condillac, the propounder of the theory that all knowledge comes through the senses, was born at Grenoble, September 30, 1715. He was a student all his days, and a recluse for most of them. He took Holy Orders, and became Abbé de Mareaux, but his true vocation was that of a speculative philosopher.

He was a friend of Rousseau and of Diderot, but his acquaintance with active life as known to these inquiring and restless spirits was but slender. His one excursion into the realm of practical affairs was a journey to Parma, at the instance of the French Court, to educate the orphan infant Duke Ferdinand, grandson of Louis XV., and it was for this Royal pupil, aged seven when the course began, that he wrote, in thirteen volumes, his "Cours d'Etudes." When he returned from Italy in 1768, Condillac was made a member of the French Academy, but only attended one meeting. Later, he lived in the country, near Beaugency, with his philosophy, and there he died, August 3, 1780.

Condillac began his studious life as a disciple of John Locke, but gradually developed a system of his own. His earliest books, the "Essai sur l'Origine des Connaissances Humaines" and the "Traité des Systèmes," published in 1746 and 1749, were expositions of Locke, and attacks on the doctrine of "innate" ideas advanced by Descartes, and on the abstract theories of Leibnitz and Spinoza. Locke had said that all human thoughts are due to experience, and experience comes through observation of external phenomena—that is, through the five senses, or else through reflection "upon the operation of mind." But Condillac ruled out the latter part of this two-fold proposition, and contended that knowledge is derivable from sensation, or the senses, only.

In his third book, the "Traité des Sensations," he further seeks to limit the origin of knowledge to sensations, excluding reflection, though he admits that sensations are modifiable by judgment. In order to attain an analytical view of the action of the senses, Condillac imagines an inanimate statue coming to life through the successive activity of each of the five senses. First, smell brings consciousness, attention, pleasure, and pain, with memory of the scent, and comparison with other scents, involving judgment. Then hearing, taste, and sight succeed, and are followed by touch, until man has become what he is, without any need for innate possession of ideas.

Condillac apparently did not see how this theory leads straight to the blankest materialism. Indeed, that is where it did lead men like Diderot, to the exclusion of all the spiritual phenomena which, from the ecclesiastical point of view, Condillac faithfully accepted. Though his psychological survey was so limited, however, seen from the modern point of view of the immanence of creative life, his exact and logical method marked an advance in men's study of the mind. At the time of his death, Condillac had in hand his "Logique," expounding an analytic method written at the request of the Polish Council of Public Instruction.

His passion for psychological analysis led him to enumerate a singular principle with respect to youthful education. "The first thing to be done," he says, "is to make the child acquainted with the faculties of his own soul, and to cause him to feel the need of making use of them." This principle he carried out in the syllabus of instruction he drew up for his princely pupil of seven by insisting that the child should study in a preliminary way (*a*) the nature of ideas; (*b*) the operations of the soul; (*c*) the

habits; (*d*) the difference between the soul and the body; (*e*) the knowledge of God. Poor child of seven! Or, otherwise, what a miraculous intellect!

Still, Condillac's views on education are often valuable as well as interesting. He speaks slightingly of learning by rote. Mnemonic prodigies are distasteful to him. The essence of good teaching is in leading the child to think. "He who has not learned to reflect has not been instructed." The gradual growth of the child through education should accord with the gradual growth of knowledge by mankind. Primary knowledge should be followed by cultivation of the taste, and crowned by philosophical speculation.

Condillac's range of interest was wide. It included economics, and his last book published during his lifetime—in 1776—"Le Commerce et le Gouvernement, considérés relativement l'un à l'autre," largely influenced later European thought. It appeared in the same year as Adam Smith's "Wealth of Nations," and Condillac, like Adam Smith, was an ardent believer in Free Trade. His way of putting the case was that exchange between nations or traders is essentially beneficial to both parties, as each is actually bartering something of the nature of a superfluity for something of the nature of a necessity.

DEMOCRITUS

The First and Greatest of the Materialists

Democritus was born at Abdera, in Thrace, about 460 B.C. He is often called the laughing philosopher, by contrast with the solemn Heraclitus, but the grounds for this view of his character are doubtful. He was born of a noble and wealthy family, which entertained Xerxes, the conqueror, on his return from Asia. The soldier left some of the Asian wise men behind him, and from them, no doubt, Democritus gained the desire to travel and learn the wisdom of the East. Upon travel he spent, indeed, his fortune, but he learned much in exchange, not least in Egypt, where he spent five years. When he came home, he gained immense fame, and was offered the rulership of the city, which he declined.

We know very little of the external life of Democritus. He is believed to have reached a great age, but the date of his death is uncertain. He wrote largely, but we only have fragments of his compositions, and are compelled to rely, to some extent, upon his followers' traditions of him.

We may call him, however, the first and greatest of the materialists, and may recognise in him the most remarkable anticipations of physical facts which have since been verified. He is the identifier of the atom, the first atomist, the founder of the physical system and explanation of Nature which may be called Atomism. He declared that matter consists of a multitude of ultimate particles called atoms—that is to say, the *uncut*. They could not be divided, but were the elements of all things.

Democritus seems to have conceived these atoms as centres of force, much as the modern chemist does. We must not attribute to Democritus such detailed ideas about atoms as we owe to his modern

DEMOCRITUS

successor, Dalton; nor must we reject his views because recent chemistry has shown that atoms *can* be divided. The fact remains that atoms do exist, and that they correspond in essentials with what Democritus declared of them.

From this first postulate, Democritus could proceed to a system of philosophy; and if we examine it we find that it is the prototype of all materialistic systems since his day. The idea of mechanical law, destiny, or fate is part of them; by law is here meant a system of mechanical working which is independent of mind in every way. Law and destiny inhere in the properties of the atoms. According to those properties are

all bodies built up, and the properties and behaviour of all things are therefore dependent upon the properties of their constituent atoms. Thus the whole of Nature is conceived as an atomic system, governed by mechanical laws.

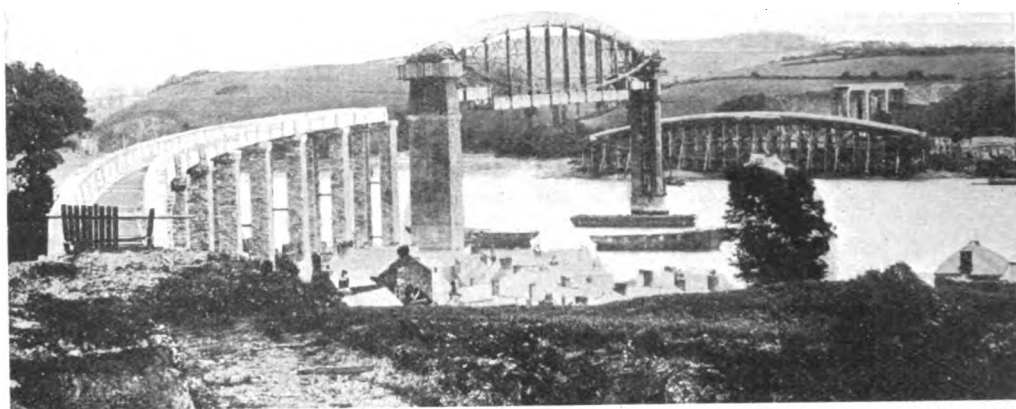
The theory is a great one, and is in many respects closely similar to that put forward by Leibnitz many ages later. It was not only great as an intellectual construction, but it was fertile. As we now know, it represents a very considerable portion of the truth; and it was thus a legacy for future thinkers and students of Nature. The idea of the atoms which constitute things and give them their characteristics became a permanent possession of humanity, and an extremely valuable one. The name of Democritus will always be honoured in connection with it. On the other hand, it seems clear that his theory was purely mechanical. We cannot find in his writings any recognition of the Intelligence, or Nous, in which Anaxagoras believed. The inherent physico-chemical properties, as we should now call them, of the atoms were to account for everything.

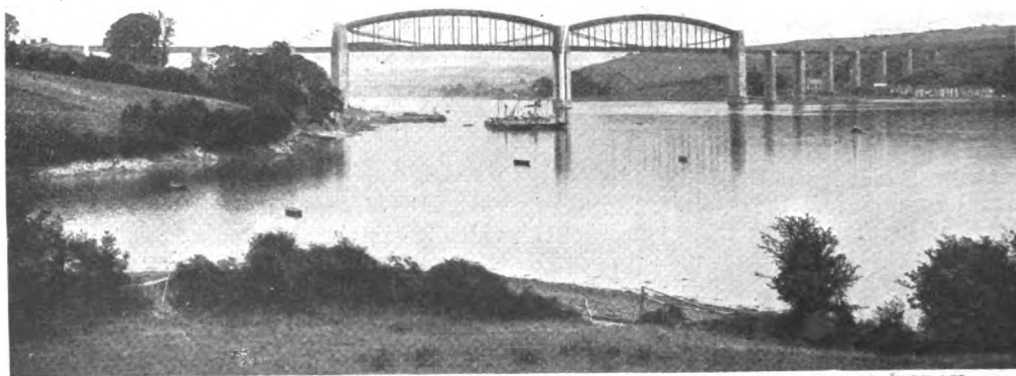
"Few great men," says Lange, the German historian of thought, "have been so despitefully used by history as Democritus. In the distorted images sent down to us through unscientific traditions there remains of him almost nothing but the name of the 'laughing philosopher,' while figures of immeasurably smaller significance spread themselves out at full length before us." This injustice is now being corrected. It is on record that Bacon, a great judge, had a very high opinion of Democritus, though he, like Lange, was an opponent of materialism. And, about a generation ago, in his famous Belfast address to the British Association, Professor Tyndall did much to teach the modern world how great Democritus was.

His memory owes something, also, to George Henry Lewes, who shows that Democritus opened out new paths in our study of the physical world, and that he made real contributions to psychology as well. It is, indeed, curious to hear Madame Montessori, and her enthusiastic advocates in this country and the United States of America, largely basing their educational theories upon the doctrine which Democritus was the first to teach—that "touch is the mother of the senses." This remarkable thinker, approaching the senses not from any study of the body, but as a philosopher, argued that all of them were none other than special developments of their "common progenitor," touch. When we see, we do not touch, indeed; but Democritus taught that things seen throw off from their surfaces a kind of image or emanation of themselves, which reaches the eye and arouses vision. Thus sight is a sort of "anticipatory touch." This is the famous theory of sensation framed by Democritus, and it becomes also a theory of knowledge. By the senses only, by touch, and specialisations of touch, can we and do we know.

The biologist and psychologist of today, studying the development of the individual, the formation of the lens of the eye from the skin, the evolution of the various sense-organs, and so forth, are bound to admit that when Democritus declared touch to be the mother of the senses he correctly anticipated what science was to prove more than two thousand years later. Upon this thinking of the ancient Greek thinker, and the evidence of today, are based most of the demands which scientific students of education are making at the present time. When the late Professor William James, and so many educators of today, such as Professor Michael Sadler, argue for more manual training in education, they are following the theory of old Democritus. The same must be said for the advocates of modelling and drawing, and, above all, for those of the latest scheme of education, known as the "Montessori system."

We have referred to Tyndall's opinion of Democritus in respect of the physical theory of the atom, which we owe to this great man. But it must be added that Tyndall definitely *rejects* the view that life and mind are to be explained on the atomic theory. He says: "If we look at matter as pictured by Democritus, and as defined for generations in our scientific text-books, the notion of any form of life whatever coming out of it is utterly unimaginable. The argument placed in the mouth of Bishop Butler suffices, in my opinion, to crush all such materialism as this." The argument referred to is one which Tyndall invents as expressing Butler's views, and points to the fact that atoms without mind and life individually might construct mindless and senseless automata, but that mind and life could not be produced from them. The evident conclusion is that we must extend notions of mind to the atoms ot Democritus, if mind is thereafter to be explained in terms of them.

BRUNEL'S TRIUMPH IN BRIDGE-BUILDING

THE SALTASH RAILWAY BRIDGE, ACROSS THE RIVER TAMAR, BEFORE THE RAILWAY WAS LAID

THE SALTASH RAILWAY BRIDGE IN COURSE OF ERECTION IN THE 'FIFTIES

THE SALTASH RAILWAY BRIDGE, ROYAL ALBERT VIADUCT, AS IT APPEARS TODAY

INVENTORS

LOUIS BRENNAN

An Inventor in Peace and War

Louis Brennan, maker of torpedoes and gyroscopic railways, was born at Castlebar, in Ireland, on January 28, 1852. At nine years of age he was taken to Australia, and he lived at Melbourne until 1880. When a young watchmaker, he took up the study of a few mechanical paradoxes, and developed a surprising genius for working them into great practical inventions. His celebrated torpedo was based on a very simple operation, and so was his still more famous mono-rail. But in both cases a great deal of ingenuity and hard work was necessary to perfect them; indeed, he is still busy working on the railway that promises to transform the conditions of locomotion and land transport.

Possessing business ability as well as a genius for invention, he was able to sell the Brennan torpedo to the British Government. In 1887 he was made superintendent of the Brennan torpedo factory, near Chatham, but at the end of nine years he was content with the position of consulting engineer to the factory, and retained it until 1907. He had taken to playing with tops, and, being now a man of fame and fortune and influence, he could afford time to study the curious action of the gyroscope. It could be put to use on a torpedo, and also on a railway train or a rolling ship. Its usefulness was of wide application; it could even, as has lately been shown, give stability to the aeroplane.

The gyroscope had been first introduced into the torpedo by Ludwig Obry, and is an important element in the Whitehead torpedo, preventing the deviation of that engine of destruction from its direct course. The peculiarity of the Brennan torpedo, for which Mr. Brennan received from the British Government the unprecedented sum of £110,000, is of another kind. This torpedo, used for the protection of docks and harbours, is propelled and steered by an exceedingly ingenious device. The torpedo contains two drums, each of which is wound with a great length of fine wire, and is geared to a propeller. These wires from the two drums are wound in at high speed by an engine on shore, and the torpedo is thus driven and directed.

Mr. Brennan had from a boy been interested in the balancing power of tops. He was born with the greatest of all possessions, a sense of wonder, and, more fortunate than the majority of mortals, kept his divine faculty through life. He was amazed at the mechanical paradox of a top-heavy top keeping an upright balance when spun. To get at the explanation, he bought all kinds of tops, made new sorts, and experimented with them for years. It was by means of these gyroscopic experiments that he obtained the master-idea of the new mono-rail, which is fully described and illustrated on page 1682 and the following pages of the present work.

The War Office, the Indian Government, and the Kashmir Government became greatly interested in the gyroscopic car. They all had railways to build, sometimes hastily, and a train that needed only a single line, narrowly, cheaply, and even roughly built, was very promising. So Mr.

Brennan received subsidies, with which he has constructed a full-sized car and a single track near the torpedo factory at Chatham.

JAMES BRINDLEY
A Canal-Maker's Romance

James Brindley, the canal maker, and one of England's greatest practical geniuses, was born at Thornsett, Derbyshire, in 1716, the son of a wastrel small farmer, who failed in all the duties of a father, and left his children without education. James eventually learnt the rudiments of spelling, and could just write his name and figure simple sums, but he relied almost exclusively upon mental processes for the elucidation of his problems. After a

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wretched childhood, he apprenticed himself, at seventeen, to a millwright, who was also something of an engineer. His master at first regarded him as a slovenly workman, and threatened to send him back to the fields from which he had taken him, but greater responsibilities brought out the lad's marvellous powers.

His employer was engaged to build a paper-making machine, and came to a standstill with the work through ignorance of his subject. Brindley, after finishing work one Saturday, voluntarily undertook a fifty-mile walk to a place where a similar machine was in existence, looked it over, trudged back to his home, was in his place when the shop opened on the Monday morning, was able to tell his employer where he had strayed, put him right, and, in the building of the machine, effected an important improvement in the mechanism. The useless lout of yesterday had become the master-mind of the establishment.

Before Brindley's apprenticeship expired, his master, grown old and decrepit, was glad to resign the control of the business to him, and Brindley ran the place, and supported the old man and his family with unswerving fidelity. Eventually he was able to start a little business of his own, ostensibly as a millwright—a very elastic term in those days. He became the general-utility man of the neighbourhood. If a machine broke down, they sent for Brindley; if, for some unexplained mystery, one would not work, though not obviously damaged, they sent for Brindley. He never failed them. While accomplishing some trifling repair, he would note an opening for some improvement, and would apply his idea. It may have been some entirely new principle, worthy the protection of the Patent Office, but he did not worry with legal protection. The thing was done in the course of the day's work, and he would not have been happy otherwise.

The fame of the illiterate millwright spread, and he was called to Clifton, in Lancashire, to pump a mine free of water. He did the pumping, but to accomplish it he had to obtain his power by a water-wheel fixed thirty feet underground, and to carry to it from the Irwell, through a tunnel some 600 yards in length, bored in part through rock.

Next he was called in to assist in erecting certain machinery at a silk-mill in Cheshire, where a pompous engineer was in charge, who frankly admitted to him that he did not understand the work that he was called on to discharge, yet treated Brindley, whom he was forced to consult, with distrust and contempt. Brindley quietly informed his employers how matters stood, and offered, if given a free hand, to carry out the work to their entire satisfaction. They agreed, and he executed his task in such a manner as to astonish them.

Incidentally, while fitting up the machinery, he noticed that the silk was unevenly wound on to the bobbins. He paused to invent valuable improvements here, so that the silk ran evenly on to the bobbins; and he contrived also mechanism by which the entire machinery of the mill could be instantly stopped, or any particular portion of it. Having much to do

with gear wheels, he realised how badly and slowly these were cut by the manual methods in use; so he invented a machine which cut them accurately, and at about fourteen times the rate previously attained.

So matters went on until a very remarkable man, the Duke of Bridgewater, heard of the untutored genius, and called upon him to build him a canal, the first serious venture of the kind in England. It was to run from Worsley to Manchester, and, to avoid waste of water and money from a system of locks, it was to be on a dead level. This meant the boring of tunnels and the raising of embankments. Moreover, the canal had to be thrown across the River Irwell. In his quiet, unemotional way, Brindley thought matters out, formed his own plans, and began. Of course, the critics sneered, as they would sneer today if a jobbing engineer were suddenly called upon to make a canal to open up one of the richest coalfields in England. When he heard of the man's proposal to construct a three-span aqueduct across the Irwell, one of the experts remarked: "Well, I have often heard of castles in the air, but never before was shown where any of them were to be erected." Brindley went quietly on with his work, tunnelling here, embanking there, burrowing under Manchester at one end and under Worsley at the other, touching the coalfield at a score of points. The aqueduct was begun in July, 1760; boats were crossing it in July, 1761.

Next the duke set him to link up Liverpool with Manchester, by continuing the canal to the Mersey tideway at Runcorn; and Brindley did it—thirty miles of canal carried over a course of infinite difficulties, including two rivers and two deep valleys, the first crossed by aqueducts and the second by broad and lofty embankments. He had not forces available such as they have had for the Panama Canal, but in the first 600 yards from the Mersey there is a rise of 82 feet, and Brindley's locks successfully negotiated it.

He had a genius for economy, for mastering difficulties by the invention of entirely new forms of apparatus. It is impossible to follow him through all his undertakings, which gave England some 365 miles of navigable canals, and placed her in a position, in regard to cheap and easy carriage for goods, which she ought never to have let slip. His works enormously stimulated industry, for coalfields which had before been inaccessible, and sites favourable to manufactures which had previously lain fallow, were now brought into communication with the rest of the world at trifling cost.

Probably England has never produced another such man as Brindley. All the complex calculations necessary for his great engineering feats were worked out, unaided, in his own head. He never made drawings, except when rarely his employer insisted on a rough sketch. He figured out quantities and details of canal or machine in his mind. When he had reached the end of a long sum from which he had to carry on, he would jot down a few figures on paper, and work on afresh from that stage. He lived for his work, had no hobbies, no recreations. Once, and once only, he went to a play. It completely upset him. It confused his ideas, he said, and unfitted him for business. Why did people want to bother with such nonsense, when there were canals to build? Canals became his grand passion.

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He once defined, before a Parliamentary Committee, his theory as to Nature's purpose in providing rivers. "They were made," he said, "to serve as feeders to navigable canals." And doubtless he believed it. He continued his cheerful labours to the end of his days, always planning, planning, in that wonderful brain of his, a brain which embraced the entire details of, say, a canal such as the Grand Junction, linking the Trent and Humber with the Mersey; embraced the details from

the cutting of the first sod to the fitting of the last lock-gates, all prepared before the first order was given.

When any specially recondite problem challenged him, he would retire to bed, and stay there, one day, two days, three days, or more, if the case needed, wrestling with his difficulties. But when he got up the whole thing would be clear, and operations would at once begin. Rough, uncouth in manner, clad as one of the meanest of his carters, when he spoke, for all his rough diction, his brief, pregnant speech was that of a genius. Carlyle's picture of him is perfect: "The rugged Brindley has little to say for himself; the rugged Brindley, when difficulties accumulate, retires silent, generally to his bed . . . that he may be in perfect privacy there, and ascertain in his rough head how the difficulties may be overcome. The ineloquent Brindley, behold, he has chained seas together; his ships do visibly float over valleys, invisibly through the hearts of mountains; the Mersey and the Thames, the Humber and the Severn have shaken hands; Nature most audibly answers, yea!" Brindley died at Turnhurst, Staffordshire, on September 30, 1772.

ISAMBARD KINGDOM BRUNEL

A Great Engineer on Land and Sea

Isambard Kingdom Brunel was born at Portsmouth on April 9, 1806, the son of Sir Marc Isambard Brunel. His father, retaining his love of French educational institutions, sent the boy to Paris, where he passed two profitable years at the College of Henri IV., which had had a high reputation for mathematics. Young Brunel, who inherited the fine talents of his father, proved himself an adept mathematician, and his gifts in this direction served him well in the great undertakings that lay before him. But he owed his practical training to England, and at seventeen entered the office of his father, who by this time occupied a commanding place as an engineer. He was still a boy when he worked for his father in the building of the Thames Tunnel, and throughout the trying operations attending that gigantic work he served with splendid devotion. He was not merely resident engineer in name but in actuality. He was never absent from the scene when danger threatened, was always ready to counsel and encourage, to repair the ravages of the river, to battle against its inrush, to save the lives of men less able than himself, and help them to keep their heads in crises. At one period he was in the workings for ninety-six hours at a stretch, with only snatched intervals of sleep taken in the actual tunnel. His experience there was a highly valuable training for his own career, for the instant solution of problems presented themselves involving engineering skill of the highest order, and he exhibited resource and versatility equalling his personal courage and zeal.

Some of his most extensive projects were carried through while the tunnel scheme hung like an incubus about his father's shoulders, and during the troublous times in which an ungenerous generation flung the great genius into a noisome debtors' prison. The son's first large scheme was

ISAMBARD KINGDOM BRUNEL

for the erection of a suspension bridge at Clifton. This was in 1829, when his first draft was not accepted. Two years later, Brunel submitted a second, and this proved so mathematically exact that it was accepted in face of the competition of the greatest engineers of the day, including Telford, by whose advice the first had been rejected. For a man of three-and-twenty, the undertaking was an arduous one, but Brunel had ripened in wisdom amid the perplexities of the Thames Tunnel. The work was begun in 1836, but, owing to lack of funds, was not carried to completion until after its designer's death. Meanwhile, Brunel embarked upon a series of notable works, the

building of great docks in various parts of the country through which incalculable wealth has since passed, and the making of railways both in England and on the Continent.

As engineer to the Great Western Railway he carried out a vast amount of work. Brunel was the chief advocate of the broad gauge, and his adherence to this plan was destined to cost his company a fortune before the narrow gauge was fully installed. But though he erred here, as also in his atmospheric railway scheme, he achieved magnificent work in all other directions. There was no Bessemer to give him abundant cheap steel for his rails and bridges and plant, no vast engineering works such as the smallest railway can command today, but with such as he had at hand he built lines, bridges, viaducts, and tunnels which, even today, after all these years, are among the glories of British railway engineering. It was due to him that the smooth-running, admirable Great Western became known among railway travellers as "the fine old English gentleman;" and the confidence that the staff reposed in him may be estimated from the tradition still treasured at Paddington that a doughty knight of the footplate solemnly submitted to the directors a proposition that if they would look after his wife and children he would drive his train from London to Bristol, 118½ miles, within the hour!

Brunel presently turned his attention to steamships, and revolutionised them in point of size, power, and efficiency. More than seventy years before Amundsen discovered how to drive a ship half way round the world without calling for fuel, Brunel was debating the same problem, and his plan was to make his vessels big enough, if need be, to store coal which would take them out and home again across the Atlantic, or farther, without recoaling. His first vessel, the "Great Western," 236 feet in length, and with a displacement of 2300 tons, exceeded by 28 ft. the largest vessel previously afloat, and at once cut down the voyage to America to fifteen days—an enormous gain both in point of time and earning power. Becoming convinced of the practicability of the screw propeller for large ships he installed the new method of propulsion in the "Great Britain," which, launched in 1845, was the pioneer of all the big screw-driven vessels. His next and last ship was the "Great Eastern," regarded by shipbuilders as the final word in seagoing craft. The story of her disasters and failures is familiar history.

The failures were not Brunel's. There was genius in his designs, but he had many unknown quantities to face in the construction of a vessel so largely out-topping all her predecessors. The double skin, first adopted in the "Great Eastern," was Brunel's invention, and its importance has been borne in upon us all in connection with the sinking of the "Titanic." The worries arising from the building of the vessel constituted Brunel's death-blow. He was seized with an apopleptic fit at the trial of her engines, and died ten days later, on September 15, 1859. As mentioned, his admirable Clifton suspension bridge was completed after his death, from materials used by him for the old Hungerford suspension bridge, which was removed to make way for the existing railway bridge at Charing Cross.

THE "GREAT EASTERN" AS DEPICTED IN A PAINTING IN THE VICTORIA AND ALBERT MUSEUM

Brunel was a man of singularly charming nature, a generous, dependable friend to his competitors, as well as to his intimates, and would say, "spite and ill-nature are among the most expensive luxuries in life."

SIR MARC ISAMBARD BRUNEL

The Pioneer of Tunnelling under Waters

Sir Marc Isambard Brunel was born, the son of a small farmer and postmaster, at Hacqueville, near Gisors, Normandy, on April 25, 1769. Vowed by his father to the Church, the boy showed himself a born artist and engineer, and early in life pawned his hat to raise the money for a new tool. The paternal views as to the Church having been abandoned, Brunel entered the French Navy, and served for six years. While at sea he invented an admirable quadrant, which served him all his life. Returning home, at the expiration of his term, he became engaged to an English girl named Sophia Kingdom. He had met her at Rouen, where she was a visitor. Her maiden name lives, it will be noticed, as the second name of their distinguished son.

The French Revolution was at its height on Brunel's return, and as the Royalist views of the young sailor placed his life in danger, he was glad to escape to America, whither many of his countrymen had preceded him. He readily found employment as surveyor and architect, and carried out important work for the American Government, by whom he was appointed chief engineer of New York.

Brunel would in all likelihood have remained to make his fortune in New York had there not been a lodestone to draw him to England. It was Sophia Kingdom. He could not be happy without the English girl whom he had met at Rouen, and as she had returned to her native land he determined to follow her. Storing his mind with ideas for inventions, he set sail, determined to stake his fortune at the outset on a device for making by machinery the blocks used in the rigging of ships. Of these blocks no fewer than 1400 were employed in the rigging of a single man-of-war, and the difficulty in getting them expeditiously and perfectly made was a constant source of worry. Brunel had thought out his scheme while himself engaged in wood-cutting; and the romance of the invention must be rounded off by repeating his assertion that the operation in question was none other than his carving the initials "S. K." upon the trunk of a giant of the American forest. So to England he came; met again his beloved "S. K.," married her, and became the father of a son in every respect worthy of them both.

In submitting to the Admiralty his scheme for block-making machinery he had the fortune to meet Sir Samuel Bentham, Inspector-General of Naval Works, who had himself devised a plan for this very work, had installed plant, and actually begun the erection of buildings for exploiting his patent. With exemplary chivalry and magnanimity, Bentham, with whom the decision lay, at once admitted the superiority of Brunel's invention, and recommended its adoption. In order to carry out his design, Brunel, who was a skilled draughtsman, but no mechanic, had to seek the assistance of Maudslay, that never-failing ally of the inventor. Maudslay carried out an extensive series of machines for the successive operations necessary, and they were duly installed at the Government dockyard—the first series of machines by which a manufacturing process was ever broken up into sections in this manner. The invention was a great success, for it reduced the cost of labour by nine-tenths, and vastly increased the output, while each piece of wood turned was mathematically accurate in design and proportions.

Brunel realised £17,000 by his invention, which was a small proportion of the saving effected for the Government in the first year of its operation. Later, when he was in difficulties, he received a further £5000, but the Government paid him ill, considering the enormous saving that had resulted to them. Brunel now gave rein to his inventive faculties, and produced new varieties of machines for cutting, sawing, and bending timber, and erected large sawmills at Battersea. It was the destruction of these mills by fire which ultimately brought him to bankruptcy. Next he carried out great extensions and improvements at the Chatham Dockyard, where he revolutionised the old-time methods. He further invented a kind of sewing-machine, and another for making boots. Again, he conducted important experiments in steam navigation on the Thames, and got the Admiralty so far towards recognising the existence of the new motive-power as to let him undertake to provide steam tugs for towing the wooden walls of Old England.

But they would have nothing to do with actual steam vessels; and after having undertaken to indemnify him for experiments, they revoked the agreement and left him to bear the entire expense himself. English history should not be read in the lives of the inventors if one would retain respect for his country. While he was

inventing new stereotyping processes, erecting sawmills and bridges at home and abroad, and unweariedly carrying on complicated experiments for the betterment of steam navigation, his Battersea mills were burnt down, and Brunel was eventually thrown into prison for debt. The Government, which had been profiting by his invention to the extent of £24,000 per annum for the preceding eighteen years, and had added to his embarrassments in the manner already described, let him lie in durance vile for months before they at last awarded him the £5000 necessary to effect his release. And while he was in prison there was the Thames Tunnel waiting to be built. The story of that tunnel, with its dif-

SIR MARC ISAMBARD BRUNEL
Photograph by Emery Walker

ficulties, its tragedies, its romance and terrors, is part of the history of engineering. The tunnel was made possible simply by reason of a characteristic example of observation on the part of Brunel. In the dockyard he noticed the operations of the teredo, or ship-worm. He saw how, in tunnelling into the timbers, it constructed a tube for itself, from its own secretion, building up its shield as it ate away the wood. Brunel invented a shield upon the same plan. As the face of the soil was dug away, the men, covered and protected by the shield, built up with masonry the roof and walls which they had cut. It was a masterpiece of invention, and all the sub-aqueous tunnels in the world since that day have been bored by its use. There never were greater engineering difficulties than those encountered in the Thames Tunnel. Again and again the river broke in upon the workers, drowning men, wrecking the apparatus, working enormous damage. Only brilliant fertility of resource and unswerving courage on the part of Brunel and his son saved the situation.

As it was, funds ran out, and the work was suspended for seven years. It was an unparalleled situation, a wonderful tunnel driven half way under the Thames, deserted, unprotected, left to crumble. A public subscription was at last raised, and Brunel was enabled finally to carry his design to triumph. The work, from beginning to end, had extended over eighteen years. It was his last great achievement, and his monument. It did not serve the purpose for which it was intended ; in some respects it was for many years his splendid failure, but in time it was put to good use as a railway tunnel, and as such it serves today. Brunel was a confirmed invalid for the last three or four years of his life, and died in London on December 12, 1849.

WILLIAM BRUNTON

A Scottish Inventor who Forgot to Patent

William Brunton, mechanician and inventor, was born at Dalkeith on May 26, 1777. His father was a watch and clock maker, and his grandfather engaged in a colliery near by. From both he acquired valuable knowledge of engineering principles and mechanics while quite a boy. When he was thirteen his opportunity for more extended operations arrived. At the time when all Lancashire was against Arkwright, a purse-proud rival made some slighting reference to that inventor's early association with the barber's shop. "Ah," said Arkwright, when he heard of it, "I will find a razor in Scotland to shave Manchester." His Scots "razor" was the cotton-mill which, in association with David Dale, he built at Lanark. Here Brunton was employed for several years in the fitting shops, and, as he began with more experience than many a man of his time, he must have been a treasure where, according to Watt and Boulton, the generality of mechanics were villainously bad workmen. At any rate, William felt himself fitted for better company, and was only nineteen years of age when he packed up and went off to Birmingham, where his great compatriot Watt had become the partner of Boulton.

Murdock and Brunton were the exceptions to the rule laid down by Boulton that Scotland could not turn out a mechanic, for Brunton became almost as great a personality at the Soho Works as Murdock became in Cornwall; and for a number of years he was one of the chief animate assets of the firm. Placed in charge of the engine department, he was not content automatically to follow out the plans of his masters in the manufacture of the new power they were giving to the world; he himself suggested many vital details. Brunton made the first engine employed for the steam ferry on the Mersey in 1814, and fitted out the first steamer that ever hauled a war vessel.

It was after this that he left his old masters to join Jessop, of the Butterley Works, where he invented his famous "steam horse," an automaton which actually walked, drawing a load up a stiff gradient throughout the winter. Then, apparently, the iron steed was over-fed with fuel, for one day it incontinently burst, with terrible results, thirteen dead men lying beside it when the wreckage was examined. Little is known of this mechanical marvel today, for its dissolution was so tragic that Brunton abandoned for ever any idea he may have had of developing it further.

When thirty-eight Brunton became a partner in the Eagle Foundry at Birmingham, and later had a share in a Glamorganshire tinworks, where he showed astounding skill, for one who had no training in metallurgy, in reducing and manufacturing metals, and in the making of improved furnaces and rolling-mills. Some of his inventions became generally adopted at home, while others were carried to the mines of other lands, to enrich shareholders at home who had never heard of William Brunton. He was a man of fertile genius, but, like many other of the happy-go-lucky, talented men of his wonderful age, took more pains with his experiments than with legal formalities.

The outcome of one such piece of carelessness was that an invention for casting iron pipes, to which he had for years devoted long and anxious thought and a considerable sum of money, proved useless. A foreigner had previously patented the idea for the making of pipes of terra cotta, and had added a caveat to the effect that the same principle could be applied to the manufacture of metals. The history of those old patent laws might have been written in the blood of broken-hearted British inventors. Towards the end of his life Brunton seems to have tired of his calling, for he invested his savings in a brewery, lost the whole, and died at Camborne, Cornwall, on October 5, 1851.

DAVID BUSHNELL
The First Practical Submarine Engineer

David Bushnell, the American founder of submarine engineering and submarine explosives, was born at Saybrook (now Westbrook), Maine, U.S.A., in 1742. Of a very original turn of mind, he was the first to combine the idea of the submarine boat and torpedo, and to bring both into action. The external shape of his vessel bore some resemblance to the upper halves of two tortoise-shells, joined together, the place of entrance into the vessel being represented by the opening of the shell at the head of the animal. The inside was capable of containing the operator, with, says Bushnell's own description, air sufficient to support him for thirty minutes without receiving a fresh supply. At the bottom of the vessel, opposite the entrance, was fixed a quantity of lead for ballast. At one edge, which was directly before the operator, was an oar for rowing backward or forward. At the other edge was a rudder for steering.

An aperture at the bottom, fitted with a valve, was designed to admit water for the purpose of descending, and two force-pumps served to eject the water when it became necessary to ascend. At the top of the craft there was likewise an oar, answering to the Nordenfeldt vertical screws, for descending or continuing at any particular depth. A water-gauge or barometer determined the depth of the descent, a compass directed the course, and a ventilator within supplied the vessel with fresh air when on the surface. The vessel carried a magazine charged with explosives, which could be fixed to the hull of the object of attack, and fired by time-fuse after the submarine had withdrawn. Alternatively, it could be discharged by a similar fuse, after being floated down upon the victim with the tide.

Minute particulars of his vessels, and of the attempts he made against British ships with them, are printed in the volume of the American Philosophical Society for 1801. Washington, in a letter to Thomas Jefferson on the subject, described Bushnell as a "man of great mechanical powers, fertile in inventions, and master of execution." Of the Bushnell submarine Washington adds, "I thought, and still think, that it was an effort of genius, but that too many

things were necessary to be combined to expect much from the issue against an enemy who are always upon guard." Details of this submarine and its work will be found on page 2760 of the present work. Bushnell, disappointed at the cool reception accorded to his submarine, went to France, but returned to his native land, settled in Georgia, and died there in 1824.

JOHN CANTON

The First Maker of Artificial Magnets

John Canton was born at Stroud, Gloucestershire, on July 31, 1718. Although destined to rank as one of the great original minds of the age which produced Galvani, Volta, and Henry Cavendish, Canton had always his livelihood to seek beyond the

JOHN CANTON

charmed empire of natural science. Indeed, he gave up two important periods of his life to the task of equipping himself for bread-winning. First he was apprenticed to a broadcloth weaver, and then, travelling to London, articled himself to a schoolmaster, who eventually took him as a partner. The period was spoken of at the time as "the golden age of electricity," yet in that age men were rubbing together silk and woollen stockings to produce electricity, and Franklin's experiment in proof of the identity of electricity with lightning had baffled all who sought to confirm it. Canton was wedded to science from his youth up, and when not teaching his scholars was experimenting and learning.

He successfully repeated Franklin's experiment, and announced new discoveries in electricity, many of them insignificant in themselves, but important as links in the chain of knowledge then being formed. Thus he showed that negative or positive electricity may be produced at will in the same glass tube; that atmospheric air may be electrified; and he prepared the way for important research as to induction. His personal needs led him to the invention of various electrical instruments which proved the parents of a numerous family.

Canton's claim to fame depends, in the main, however, upon his discovery of a method of making artificial magnets, the first ever known to the world. He had been experimenting for three or four years prior to reading his paper on the subject before the Royal Society, who marked their sense of its value by awarding him the Copley medal, he having, two years earlier, been elected a Fellow. The idea of the artificial magnet occupied other minds than Canton's, and one of his rivals, who discovered several new processes of this kind, charged Canton with imitation.

It is, however, well established that Canton's claim to priority is incontestable. It is asserted that he would sooner have communicated his invention to the world but for the fact that a friend turned the knowledge to account by touching needles for compasses. Canton's other experiments led him to successful investigations of phosphorescent substances, and to a demonstration of the compressibility of water, in disproof of the commonly accepted teaching of the Florentines. Canton, who, to the end was an industrious schoolmaster, did all his research and experimental work in his leisure. He died in London on March 22, 1772, having greatly advanced electrical knowledge by his labours.

EDMUND CARTWRIGHT

The Man who Revolutionised an Industry

Edmund Cartwright was born at Marnham, Nottinghamshire, on April 24, 1743, and educated at Wakefield Grammar School and at University College, Oxford. The man who was to revolutionise cotton manufacture in England by adapting machinery to weaving was a country parson, chaplain to a couple of noblemen, and, for a while, a private tutor. To the outside world he was a poet, and brother of Major John Cartwright (1740-1824), a courageous reformer who dared to declare his country wrong in her quarrel with America, and who fought and suffered for the political freedom of his

generation. To Lord John Russell, to whom for some time he acted as tutor, Cartwright was poet first, inventor afterwards. Writing in 1822, a year before the death of the inventor, the statesman recalls that it was from Cartwright that he acquired a taste for Latin poetry. He refers to him as a man of much learning and mechanical ingenuity, "who invented a machine for carding wool, and a model of a boat which was moved by clockwork, and acted on the water by a paddle underneath." But Russell said not a word of the power-loom which was yearly adding millions to the national wealth.

Cartwright may be considered, as an inventor, the son of Arkwright. He himself has left an interesting narrative of the manner in which he was led to take up the subject. Hearing it said by a Manchester man that Arkwright's invention would lead to the spinning of so much cotton that there would not be men enough to weave it, Cartwright suggested a weaving-machine. "Impossible!" said the other. Cartwright replied that, having recently seen an automaton playing chess in London, he was convinced that it was not more difficult to make a machine which should weave than one that effected all the variety of moves required in the complicated game of chess.

When he began his work, he had had no practical experience of weaving, and indeed never actually witnessed the process of hand-loom weaving until he had completed his machine. We have a pleasant picture of the parson turned inventor, of his pacing about his garden, deep in thought, swinging his arms to and fro as he worried out the problem of weaving.

His first machine was a remarkable contrivance for an initial venture, though, as he himself shows, it was hopelessly primitive. "The warp was laid perpendicularly, the reed fell with a force of at least half a hundredweight, and the springs which threw the shuttle were strong enough to have thrown a Congreve rocket. In short, it required the strength of two powerful men to work the machine, at a slow rate, and only for a short time." Having completed his own machine, he went now to see how men really wove, realised his shortcomings, then set to work on a new and improved machine, which he patented in August, 1787, a little more than two years after his first invention.

Finding manufacturing opinion against his loom, he, like Arkwright, established a factory for himself at Doncaster, for spinning and weaving, where, after working on a limited scale, he installed a steam-engine. His success brought him an order from a Manchester firm for four hundred of his machines, but the mill in which they were set up was burned to the ground. The "no machinery" fever was at its height, and the disaster at Manchester is supposed to have been the outcome of the movement.

Cartwright next turned his attention to the woollen industry, and invented a wool-combing machine which substituted mechanical for manual action, greatly increased the output of work, and lessened the cost of labour. Here again he was met by the fanatical opposition of the workmen, and fifty thousand of them petitioned Parliament to forbid the use of the invention. Parliament declined to interfere, and in 1800, when the patent had nearly run out, acceded to his petition for a renewal in order to recoup him for his losses in connection with this and the power-loom. His losses, indeed, amounted to some £30,000, and he was compelled to surrender his Doncaster factory to his creditors.

He continued with unabated ardour to work at his inventions, producing steam-engine improvements, better agricultural implements, and rope-making machinery, while at the same time devoting considerable attention to farming in its scientific aspects. It was not until 1804, when his patent for the power-loom expired, that the invention was permitted to show a profit. Then, however, he found that Lancashire manufacturers were growing rich upon the product of his brain, and for once in his life he expressed himself indignantly upon the subject. The upshot was that the Manchester men who were benefited by his invention asked the Government to reward the inventor. The outcome was a grant of £10,000. This, though but a small return for the losses that he had incurred in making a rich nation richer, kept Cartwright in comfort to the end of his days. To the last he invented and wrote poetry. He died at Hastings on October 30, 1823.

ANDERS CELSIUS

The Man who Invented the Thermometer Used by Science

Anders Celsius was born at Upsala, Sweden, on November 27, 1701. Grandson of a noted Swedish astronomer, and nephew of a professor of theology, Celsius at nine-and-twenty became professor of astronomy at the university of his native town. Upsala at this time lacked an observatory, and Celsius, two years after appointment to his Chair, undertook a tour of inspection of the

chief European observatories. In the following year he published a striking series of observations of the aurora borealis, the fruit of his own labour and that of others during the preceding sixteen years. He was temporarily released from his professorial duties in order that he might, upon his own suggestion, extend his travels to Lapland, and there, with a scientific party, measure an arc of the meridian. Four years later the admirable observatory of Upsala was erected, embodying all the suggestions which his experiences of similar institutions in Paris, Rome, and Nuremberg had enabled him to make.

It was while he still directed the astronomical studies of the Upsala University that he constructed and exhibited the Centigrade thermometer, which has since become generally famous. It differs from the Fahrenheit thermometer, commonly used in England and America, by rating the freezing-point as zero, lower temperatures being minus, while the boiling-point is 100. Fahrenheit's instrument, of course, gives 32 as freezing-point, and 212 as boiling-point. The Centigrade scale is mainly employed for scientific purposes.

The thermometer of Fahrenheit is preferred for ordinary purposes as being simpler, from the fact that its degree is smaller, reading to tenths. That is to say, a tenth of a division of the Fahrenheit scale has to be read as roughly a half-tenth on the Centigrade; and even then the difference is not clearly indicated, for 9 degrees of Fahrenheit represent 5 degrees of Centigrade; while a third thermometer, the Réamur, shows only 4 degrees for 9 degrees of the Fahrenheit scale.

Nearly a century ago Croker made persistent efforts to secure the adoption of one common thermometric scale. Other means of gaining his end failing, he sought to get the question discussed by the delegates to the famous Congress of Vienna. He believed that he would have succeeded but for an unlooked-for event: Napoleon escaped from Elba, and, upon touching the soil of the mainland, declared "The Congress is dissolved." So we still have our three scales. Celsius, who wrote several important works on astronomy, died at his native town, Upsala, on April 25, 1744.

SIR WILLIAM COOKE

Joint Inventor of the Electric Telegraph System

William Fothergill Cooke was born at Ealing, Middlesex, in 1806. Educated in Durham and at Edinburgh University, he entered the Indian army at twenty, served five years in the Dependency; then, intending to follow his father, who was a doctor, underwent a course of study in Paris and Heidelberg. This was an important and profitable period of his career, for he was enabled to master the details of all the attempts which had up to that time been made to render electric telegraphy a practical means of communication. Professor Müncke, under whom he studied at Heidelberg, had traced developments step by step, and succeeded at once in interesting Cooke in his studies of the subject.

Cooke's was not a creative genius, but he was intensely practical. He saw at once that a marvellous toy of the laboratory might be turned to account, among other purposes, for railway signalling, which was then chaotic to a degree inconceivable today. The engine-driver advertised his approach at night by a light in front of his engine; while another, affixed to the last coach, warned off attacks from rearward. He got hand-signals by day, from flags or semaphores; lamps guided him at night, or a lighted candle, stuck in the window of the station-master's house, bade him stop; while a darkened window signified "All clear." News of the birth of the future Edward VII. was carried through the Midlands by special engine, and given out at successive stations by the driver. Cooke saw that he could alter all this.

While Cooke was thinking out plans for applying electric telegraphy, and negotiating with railway companies, Wheatstone was quietly working in England at the task of perfecting an instrument. It was the good fortune of the two men to be brought together by Faraday. Cooke had a method of his own, crude and impractical as it proved, a modification of that of Baron Schilling, who had devised a scheme for the use of five wires and two needles. Wheatstone was able to effect important modifications; and the two men, entering into partnership in May, 1837, took out their first patent in the following month. The first plan necessitated the use of five wires and as many needles, and was abandoned as hopelessly costly. Next they tried only two needles, and then only two wires, and this method was in operation in 1840. Five years later they produced their single-needle apparatus.

That same year a man named Tawell committed a murder at Salthill, and escaped from Slough to London. News of his flight was wired from Slough to

Paddington; Tawell was arrested, tried, and hanged. And people travelling along the line used afterwards to point to the telegraph wires and say: "Them's the cords that hung John Tawell!" Just as the arrest of Crippen in our own day, effected through a description sent by wireless to the ship by which he was fleeing, for the first time really brought home to the mind of the world the enormous potentialities of the new science, so the apprehension of John Tawell, the Quaker murderer, in 1845, made men understand that with the telegraph a new force had come into the world.

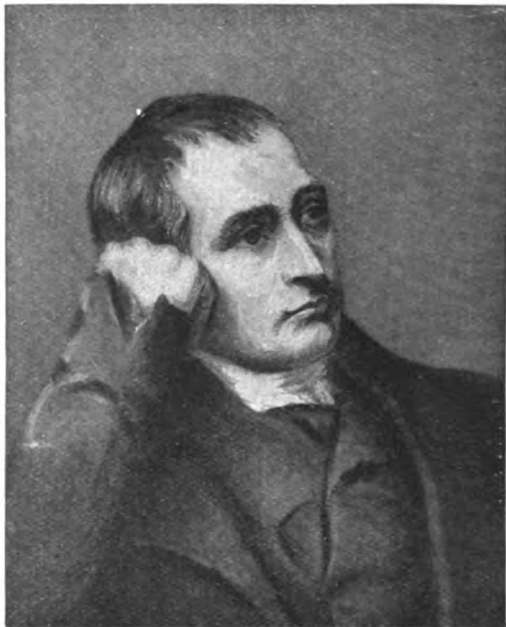
From the railways to the general purposes of everyday life the telegraph soon spread. The two partners quarrelled as to which had had the greater share in inventing the single-needle instrument; and the verdict of history is that Wheatstone was right when he said that he could not so soon have succeeded without the help of Cooke, but that, without him, Cooke never could have succeeded at all. Cooke was the great organiser of the scheme, the practical man of business; Wheatstone's was the originating mind, in so far as the science of the undertaking went. But Cooke did great work for telegraphy.

In its earliest stages he nearly compassed the thing that we are now seeking to achieve; he tried to put his wires underground. He laid them in pipes and insulated them in pitch. But the pitch cracked, the current leapt from wire to wire, and he was driven to suspend his wires on poles. Had he been able to command a supply of gutta-percha as an insulator, there would not have been a telegraph or telephone wire up in the air today, and we should not have been periodically isolated from Scotland and other parts of the land when gale or snowstorm rages.

When, in 1843, the partnership between Cooke and Wheatstone was dissolved, Cooke took over the patent rights, with a royalty reserved to the other. Later, when the Electro-Telegraph Company was formed, £120,000 was paid for the Cooke-Wheatstone patents. The business side of the undertaking was managed with considerable skill by Cooke, but he achieved no invention of importance after parting from Wheatstone. An application by Cooke for the extension of his patent rights on the ground of insufficient remuneration during the validity of the patent was rejected by the Privy Council. The Albert gold medal was awarded on equal terms to both men, and both in turn were knighted, while towards the close of his life Cooke was awarded a pension. He died at Farnham on June 25, 1879.

SAMUEL CROMPTON

The Man who Gave the Public the Spinning-Mule

Samuel Crompton was born at Firwood, near Bolton, on December 3, 1753. His father combined farming in a very small way with yarn-spinning, and, with his wife, occupied in the capacity of caretaker, an old family mansion known as Hall-i'-th'-Wood. Crompton the elder died when the boy was five years old, but Robert's mother, though stern and harsh, looked to the boy's gaining full advantage from a day-school, where he was better grounded in elementary studies than the general run of lads of his standing. Crompton had to devote all his leisure to the spinning of yarn for quilting; and the inadequate jenny which he had to work was a constant source of trouble, causing him to revolve in his mind schemes for making a better machine for his own service. Of an ingenious turn of mind, he made a violin, and, teaching himself to play, derived from this source his only solace. That fiddle produced great results.

SAMUEL CROMPTON

Crompton played sufficiently well upon it to gain an engagement in the orchestra of a theatre at Bolton, where he earned eighteenpence per night. With these eighteenpences he bought tools and materials for the new machine which should enable him more easily to spin yarn for himself. Working during the day at his spinning, playing his fiddle at night at the theatre, he toiled in secret at his home when others

were sleeping. For five years this went on, without aid, advice, or sympathy. At first, when dim lights were seen glimmering from the upper windows of the old mansion, and strange sounds were heard to issue, people in the neighbourhood declared that the ancient Hall-i'-th'-Wood was haunted; but when they heard that lights and noises were associated with the labours of a young man who toiled far into the night with bits of wood and wire, they decided that Crompton was a conjurer, and by that style he became known. But Crompton had good reasons for keeping his experiments secret.

The "men, not machinery" cry was running through the land, and machine-wreckers were abroad. Repeatedly the young inventor had reason to believe himself in danger. He cut a hole through the ceiling of the room in which he worked, so gaining a hiding-place for his model in the room above; and when trouble was brewing in the neighbourhood he would take his machine to pieces and hide its members in this secret fastness. At last, after five years of arduous toil, he found himself penniless, but with a practicable machine. It became known as the muslin wheel, or the Hall-i'-th'-Wood wheel, but he, recognising it as a cross between the inventions of Arkwright and Hargreaves, called it the mule. The important feature of the machine was a contrivance evolved entirely by Crompton during his long vigils.

The great and important invention of Crompton, says his biographer, was his spindle-carriage, and the principle of the thread having no strain upon it until it was completed. The carriage with the spindles could, by a movement of the hand and knee, recede just as the rollers delivered the elongated thread in a soft state, so that it would allow of a considerable stretch before the thread had to encounter the stress of winding on to the spindle. This was the particular merit of his invention. The product of this machine was infinitely finer than that yielded by the machines of Arkwright and Hargreaves.

Knowing that his work was well and truly done, Crompton felt that fortune lay ahead, so married a young woman of good but impoverished family, because she was an expert hand-spinner, and competent to help him with the spinning by his machine. The poor inventor had no money wherewith to patent his invention; and though he had here a machine which was of incalculable value to the world, he had to try and work it in secret, and derive compensation simply from the prices realised by the splendid quality of his yarn. But spies gathered about his home, determined to wrest from him the secret of his success. Arkwright is said to have been guilty of this ignoble prying. Crompton's description of his plight after the first few months is pathetic: "I was reduced to the cruel necessity either of destroying my machine altogether, or giving it to the public. To destroy it I could not think of; to have to give up that for which I had laboured so long was cruel. I had no patent, nor the means of purchasing one. In preference to destroying it, I gave it to the public."

In taking this step, he acted upon the advice of a Bolton manufacturer who, not disinterestedly, counselled him to make the machine known, and induced eighty firms to promise the inventor a guinea apiece for the secret. All told, Crompton actually realised sixty guineas, and for that gave up his model. As soon as the secret was out, money ceased to reach the inventor. The mule was everywhere installed, and great fortunes accrued from it to all but the man who had given five of the best years of his life to its creation.

With this small sum, Crompton rented a little farm near Bolton, where he continued spinning. He took certain hands into his service, but soon tired of this, as he preferred to rely upon the labour of his own family, rather than that of people who, as soon as he had taught them, were seduced from his service. In a fit of gloom at his lack of success, he smashed his own machines as well as a new carding-machine that he had invented. "They shall not have these as well," he said bitterly.

A great trade in muslins sprang up from the use of Crompton's mule, and a "conscience money" subscription was raised, from which he received four or five hundred pounds. Too proud to serve men who were reaping rich harvests from the creation of his brain, Crompton struggled on until the Government made its £10,000 grant to Cartwright, inventor of the power-loom. Then he bestirred himself with a view to gaining recognition. He set out to investigate, and found that whereas 156,000 spindles were used on the Hargreaves jenny, and 311,000 on Arkwright's machine, over 4½ million were used on his mule.

His travels took him to Glasgow, where an important trade in muslin had arisen from his invention, but, though invited to a public dinner in his honour, he could not face it. "I first hid myself," he says,

"and then fairly bolted from the city." He did, however, present a claim to the Government, and was in 1812 awarded a beggarly £5000. With this he engaged unsuccessfully in cotton manufacture. Three years before his death the manufacturers of Bolton raised a subscription, out of which they bought him an annuity of £63. This national benefactor died at Bolton on June 26, 1827.

LOUIS JACQUES DAGUERRE
A Successful Pioneer of Photography

Louis Jacques Mandé Daguerre was born at Cormeilles, near Lisieux, France, in 1789. First engaged as officer of the inland revenue, Daguerre turned to art, and distinguished himself as a scene-painter for the opera, afterwards undertaking, in company with another artist, the painting of panoramic views of famous scenes and cities. He next "invented" the diorama, a form of entertainment which, up to a few years ago, occupied in the affections of children and provincial audiences the place now commanded by the cinematograph. It was while working out his admirable effects of light and shade for these pictures, effects gained very largely from studies in the camera obscura, that Daguerre prepared the way for his later studies in photography.

"Daguerrotype" is an almost unknown name to the present generation, but it preserves for us the title of the first photographs that ever existed; and there lives today, in Lord Avebury, the first person in England to have his portrait taken by the process Lord Avebury was a child of five when Daguerre, bringing his diorama to London, visited the Lubbock household, and, seeing the future naturalist playing on the lawn, snapshotted him. But many years of study by many men had gone to the making of that picture.

The papers of Leonardo da Vinci suggest that his "preternatural knowledge" embraced the principles of photography; and, in a later day, Wedgwood, Davy, and Watt had toiled with heavy hearts at experiments on the action of light upon nitrate of silver. Indeed, there exists at the South Kensington Museum an old silvered copper plate bearing upon it a representation of the famous Soho Works of Boulton and Watt. The plate was discovered among some lumber of Boulton's, nearly seventy years after his death; and there is a record of a "sort of photograph" that Watt used to take in a dark room—probably a camera obscura; while a letter is said to have been written by Sir William Beechey to the Lunar Society—which Boulton founded—begging that these experiments in photography might cease, lest the art of the portrait-painter should perish. But the profit of the invention fell to Daguerre, who was not the sole inventor.

While he was groping towards something in the nature of photography, two brothers named Niepce, men of modest means, were quietly working at the problem on their small estate at Chalons—working there at things untried before, to the wonder of the yokels, who used to look into the little workshop and jeer, as, in a later day, other yokels were to look into a Dayton workshop and jeer at the two brothers who were mastering the problem of mechanical flight, One of the brothers, Joseph Nicéphore Niepce, from experiments in lithography, proceeded to engraving upon metal plates, and from that to imprinting images by sunlight. It was haphazard work. He drew a bow at a venture, and sought to advance from the point at which his arrow fell; and while all the rest of France was asking—for it was 1814—"Will tomorrow's sun shine upon the triumph or the enslavement of our country?" Niepce was asking, "Will tomorrow's sun produce any effect upon the process that I discovered yesterday?"

By some happy chance, Niepce and Daguerre learned that they were on the track of the same discovery. Niepce had prepared the way; Daguerre went in and completed the work. In 1824 Niepce had reached this point: he could fix an image by employing bitumen and oil of lavender spread upon a copper plate silvered over. But the plate took ten hours to receive the impression! Daguerre and Niepce met, entered into a partnership, and Daguerre carried on the invention from the point to which Niepce had brought it. Niepce died before success was finally achieved, "without glory, forgotten by his fellow-citizens, with the bitter thought present in his dying hours of having consumed twenty years of his career, dissipated his patrimony, and compromised the future of his family in the pursuit of an idea."

Left alone, Daguerre proceeded rapidly with the work, and, by a discovery as remarkable and romantic in its way as that which later led to the revelation of the X-rays, made photography practicable. Plates which had been insufficiently exposed to the light were placed in a closet where chemicals were stored, the plates thrown away as useless, because no image had

appeared. Later, Daguerre chanced to look afresh at the discarded plates, and found—pictures. He realised at once that the result was due to chemicals, and, putting in similar plates, he withdrew the chemicals one by one until he found that the effect was due to an open dish of mercury, which gives off vapour at an even temperature.

This was the cardinal point in Daguerre's discoveries, a marvellous accident, turned swiftly and skilfully to account. It made photography immediately possible, and the rest of his work served but to better the results gained from this chance discovery. He gave his own name to the photographs produced by this method, and, so far as public acknowledgment went, ignored the

LOUIS JACQUES DAGUERRE

share which his dead partner had had in leading him towards his goal. However, when compelled to make public his discovery, Daguerre received a pension of 6000 francs; the work of Niepce also was remembered, and his heir was awarded an annuity of 4000 francs. Daguerre died near Paris on July 12, 1851, by which time photography had spread into all civilised lands, and had improved almost beyond identification with his process.

GOTTLIEB DAIMLER

The German who Made the First Motor-Car

Gottlieb Daimler, the father of the motor-car, was born at Schorndorf, Würtemberg, in 1834, and from his youth up was an ardent student of practical engineering methods. Determined to gain the best experience possible, he quitted Germany for England, and secured employment with Sir Joseph Whitworth and other noted engineers. He extended his practical knowledge by varied work in German machine-shops, and at thirty-six years of age joined Dr. Otto, and assisted him to produce the famous Otto gas-engine. For a dozen years he remained with Otto, and in that time became a director of the firm. Then there occurred to Daimler the brilliant idea of adapting the Otto internal-combustion engine to the propulsion of road vehicles.

The then existing internal-combustion engines were substantial, and slow-running, making a maximum of but 250 revolutions per minute. Daimler decided that he could greatly accelerate the speed. Engineering opinion was against him. The engine would not stand up; it would over-heat, and destroy itself. But Daimler did that which so many other inventors have had to do—he made the engine which was said to be impossible. He constructed a small, light engine, of from three to four times the maximum speed of the Otto. It was a success, and he applied it, in 1886, to a bicycle, and ran it, with supreme joy, for three years, when he built a second engine, which gave him double the power and smoother running.

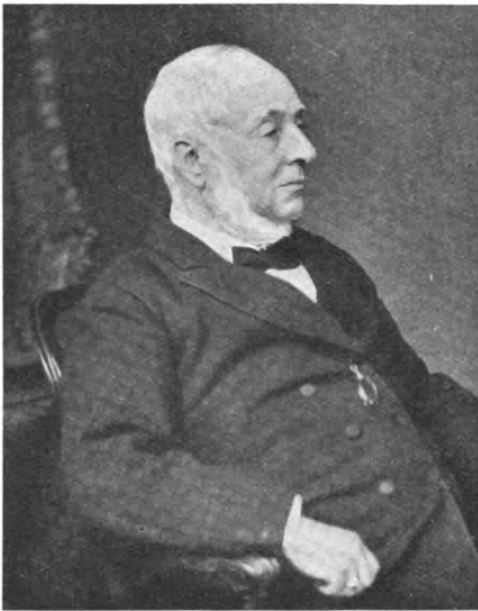
It was this second engine that the French pioneers acquired, and from it all other petrol-driven cars are descended. Levassor's ingenious mind devised the system by which power is still transmitted to the road-wheels, but the engine was the creation of this ingenious German. Daimler died in 1900, when motor-cars, though common on the Continent and in America, were still little known in England. Hence, although his name is perpetuated here by one of the finest makes of cars, he is merely a name to a majority of the vast number of Englishmen who motor. Some day he will take his proper place among the great pioneers of inventions which have revolutionised the world. For the internal-combustion engine has given us not only motor-cars and motor-cycles, but aeroplanes, airships, motor-boats, and the means of propelling the modern sea-going submarine.

WARREN DE LA RUE

The Man who Took the First Sun Photograph

Warren de la Rue was born in Guernsey on January 15, 1815, and after being educated in Paris entered the firm of his father, Thomas de la Rue, who was established in

London as the foremost of artistic printers and stationers of the period. The elder De la Rue was a man of considerable inventive faculties, but he was eclipsed by his more talented son. That son, who became chief partner in the firm, is an excellent example of the successful business man who while at the head of a commercial enterprise finds time to carry out research work in science of first-rate importance. While toying with chemistry and physics he was creating practically new industries in connection with his business, by bringing electrotyping to commercial success, by inventing machinery for the manufacture of stationery, and so forth.

The results of much patient labour were

WARREN DE LA RUE
Photograph by Maull & Fox

privately published for the benefit of learned societies with which he was associated, and his association with Wilhelm Hofmann led him into fields in which Sir William Perkin was destined deservedly to reap the harvest of synthetic dyes. While De la Rue was flitting from flower to flower in his garden of science, James Nasmyth laid hands upon him, and turned his attention to the heavens. De la Rue took up astronomy with infinite zest, built himself an admirable little observatory, made himself a thirteen-inch reflecting telescope, and, having seen a daguerrotype of the moon, turned to celestial photography.

Taking advantage of every new photographic process as the art developed, he not only furnished his generation with a superb series of photographs of the moon, but invented an instrument, known as the photo-heliograph, by which the long series of sun-photographs now in existence was begun. He threw new light upon knowledge as to the moon, and also upon the nature of sunspots, and from his expedition to view the eclipse in 1860 was able to demonstrate that the red flames, or prominences, observed during eclipse belong not to the moon but to the sun. High praise is accorded to De la Rue by Sir Norman Lockyer, who has since made the study of sunspots his own, and has had thousands of photographs of the sun taken, not only in England, but in India and elsewhere. As he says, the undertaking may seem a little futile to the man in the street, but its utility will become apparent if the work results in our being able to predict famine years in India or Egypt, and, warned betimes, take steps to guard against the calamity.

To De la Rue belongs much credit for inaugurating this work. The strenuous character of his labours, extending over many years, at last compelled him to give up astronomy. He turned again with avidity to chemistry and electricity, and his researches and experiments upon the electric discharge through gases yielded data which cannot have been without profit to the men who, coming later, have wrought miracles with the Crookes tube. De la Rue, who gave as ungrudgingly of his fortune as of his time and energy to the promotion of knowledge, held many distinguished positions in the scientific world, and continued to take an active share in his business, with a slight break, until 1880. He died in London on April 19, 1889.

RUDOLPH DIESEL
Inventor of a New Oil-Engine

Rudolph Diesel, the inventor of the famous engine that has made motor-ships possible, was born, of German parents, in Paris, on March 18, 1858. He studied in the French capital until the outbreak of the Franco-German War led his parents to migrate to England. Instead of accompanying them, the twelve-year-old boy was sent to school at Augsburg, in South Germany. The remarkably brilliant way in which he passed his examinations, and did his work, attracted the notice of Professor von Linde, who induced him to choose, as his principal study, the new science of thermo-dynamics, that deals with the relations between heat and work. Here the young student so distinguished himself that in 1879 Linde took

him as an assistant. The master was then engaged upon his now well-known plant for producing extreme degrees of coldness, by means of which liquid air is now obtained at the price of one-and-ninepence a litre.

Diesel took a practical part in the development of Linde's refrigerating machinery, and this broadened his knowledge and quickened in him the desire for practical experience in engineering. So he entered the machine-shop of Sulzer Bros., in Winterthur, Switzerland, and worked there for a short time. He was then placed at the head of the French company for constructing Linde's refrigerators in Paris.

To a young man with his special knowledge the position was an easy one, but his life in Paris was one of fierce and incessant labour. While a student he had taken up the study of the steam-engine, in the hope of finding some way of increasing the output of work obtained from a given quantity of fuel. Sadi Carnot, the founder of thermo-dynamics, had clearly pointed out the deficiencies of the modern prime mover, and contrasted it with a perfect engine that would give out in work all the energy of heat supplied to it. This was, of course, an impossible standard of perfection, but, on brooding over it as a student at Augsburg, Diesel had formed the plan of devoting his life to finding a prime mover with a much higher heat-efficiency than the steam-engine possessed. All his leisure time was given up to researches and calculations and drawings of the engine of his dreams. It was not until 1893 that he succeeded in working out his ideas to his own satisfaction. Even then he was in the unfortunate position of not having sufficient money to build the new engine he had designed. But in the hope of exciting the attention of the engineering world he published a pamphlet on "The Theory and Construction of a Rational Heat-Motor." This had the happy effect of provoking a discussion in Germany; and Friedrich Krupp, the famous cannon-maker, and H. Butz, the chairman of the Augsburg Machine Works, became interested in the ideas of the young inventor. They placed at his disposal the means for a practical development of the new engine, and Diesel built an experimental model, and at last got it to work as he wished. On June 16, 1897, he read a paper before the National Society of Engineers of Germany, in which he described a twenty horse-power oil-engine of a new kind that could be seen working at Augsburg.

Among those struck by the achievement of the young scientific engineer was Lord Kelvin, and on his advice a Scottish firm of engine-makers acquired the right to build a Diesel engine. This was done as quickly as possible, and the oil motor is still working very well. The latest Diesel engines are now being designed to work with tar as well as with the cheapest residue oils, and Dr. Diesel himself believes that the tar-engine will become of great importance in England and other countries where large quantities of tar are obtained as a by-product from coal-gas. The chief difference between his engine and the ordinary petrol or alcohol engine is that the vapourised fuel is not exploded in order to produce the working energy. It is merely burnt. Moreover, no ignition device is necessary.

Combustion is obtained by admitting a charge of air into the cylinder, and then compressing it with the return stroke of the piston until it becomes very hot. So hot does it become that it sets alight the charge of vapourised oil or tar which is next injected into the cylinder by an automatic pump. At present the pumps and other fittings tend to make the Diesel engine expensive in smaller sizes for marine purposes. But there are now several big motor-ships which are driven very economically by the new prime mover, and it is generally expected that Diesel engines will be largely used in warships and passenger and cargo boats. The saving of space in doing away with the coal-bunkers is one of the main factors of advantage which the Diesel engine possesses over the steam-engine for marine work. On land, the higher efficiency of the new motor is making it one of the most popular of prime movers; and if the price of tar and heavy oils does not mount too high, it may be able to compete with gas-engines and producer-gas engines on favourable terms. Dr. Diesel is at present engaged in designing a small and economical type of his motor for use in places where only a little power is required.

JOHN DOLLOND

The Strange Story of the Refracting Telescope

John Dollond was born in London on June 10, 1706. He was of Huguenot stock, his parents having fled from Normandy in 1685, on the Revocation of the Edict of Nantes, and, along with many other refugees, established themselves as silk-weavers in Spitalfields. Dollond, left fatherless at the age of five, had early to apply himself to the loom, but studied

industriously in moments stolen from his labours, and made considerable progress in languages, in mathematics, optics, and astronomy. He married early; and though he set up in business for himself, the needs of an increasing family necessitated his devoting himself with still greater assiduity to his profession. Yet he managed to pursue his studies at night, and, as his son Peter grew up, led him by the educational ladder which he himself had followed. The upshot was that Peter Dollond, on attaining manhood, relinquished the family business, and set up as an optician.

John Dollond carried on the weaving business for some years, but ultimately threw in his lot with his son, and rapidly

JOHN DOLLOND

acquired proficiency in his new calling, for which, indeed, his long course of study had well equipped him. It is a curious coincidence that, whereas Newton had for seven years to desist from his mighty speculations until he could get an approximately accurate estimate of the earth's dimensions, so, through an inaccurate speculation of his own, he seriously retarded the creation of a successful refracting telescope. Newton's experiments led him to believe that the object seen through the refracting telescope must always be confused in outline, owing to such object being surrounded by a rim of prismatic colours. Reasoning from the "Eighth Experiment" described in his "Opticks," his conclusion was that the defect discovered was inherent in refracting glasses, and that the confusion of outline by prismatic colours was inevitable. It is probable that Dollond would never have been led to his immortal achievement had not this law of Newton been assailed by Euler. The latter, after years of experiment, published a short paper in the "Berlin Memoirs" enunciating the view that, proceeding upon a certain law as to the relation between the refractive and dispersive powers of glass, a lens could be made which would correct colour aberration. Dollond, a devout Newtonian, was shocked that the authority of the great man should be challenged. It seemed to him presumption that, Newton having once gone over the ground, any other mortal should now, as he said in a paper published in answer to Euler, "attempt to do that which so long ago has been proved impossible." Strange words from the very man who was to prove the "impossible" practicable.

In 1754, Klingenstierna, an eminent Swede, showed that the Newtonian principle was, in extreme cases, incompatible with the phenomena, and could not, therefore, be accepted as an irrefragable law of Nature. The contentions of the three men aroused the attention of scientific Europe. Neither Euler nor Klingenstierna could reduce his theories to practice, and the world waited for a refracting telescope, because Newton, on the strength of the "Eighth Experiment," had so long before said that a perfect one could not be made. The faithful Dollond set himself, therefore, not to make the "impossible" telescope, but to confirm his great master's dictum. And the result was that he did make the impossible telescope!

By using a hollow prism, filled with water, in conjunction with an ordinary glass prism, he succeeded, by nice adjustment as to refracting angles, in abolishing the prismatic ring of distorting colours. The refracting telescope was at the disposal of the world. Later experiments enabled him to dispense with the water prism, and, by employing crown glass and flint glass of different dispersive powers, to perfect his instrument. He effected many other important improvements in relation to telescopic and other lenses; but the chief work of his life was his achromatic, or colourless, telescope, which, as it were, gave men a new sense. Dollond's son Peter, famous in his own right as an optician, reaped the profits of his father's invention, but not without a legal contest.

Suing one who had infringed his patent right, he was staggered to learn that his

father's invention had been anticipated by thirty years! Chester More Hall, of More Hall, Essex, ignorant of the controversy that was stirring scientific Europe, had quietly made an achromatic telescope as a scientific toy. He was not a party to the litigation, but the defendant brought out the facts, which were beyond dispute. Happily, Lord Mansfield held that "it is not the person who locks up an invention in his escritoire that ought to profit by a patent for such an invention, but he who brought it forth for the benefit of the public;" and Dollond, he held, was legally the inventor. Dollond, who during his closing years enjoyed prosperity and honours, died in London on November 30, 1761.

JOSEPH EMERSON DOWSON
Inventor of the Cheapest Coal-Gas

Joseph Emerson Dowson, the inventor of Dowson gas, was born in London, September 26, 1844, and educated in France and at Dulwich College. It occurred to him in 1879, when gas-engines were coming largely into use, that these engines might be used with a very cheap gas, if a suitable generating plant could be devised. For many years furnaces had been fired by gas instead of a coal fire; the gas was made on the spot in a producer plant, and sent straight into the furnace. In this case there was no need to cool and clean the gas and free it from tarry vapours. But for engine

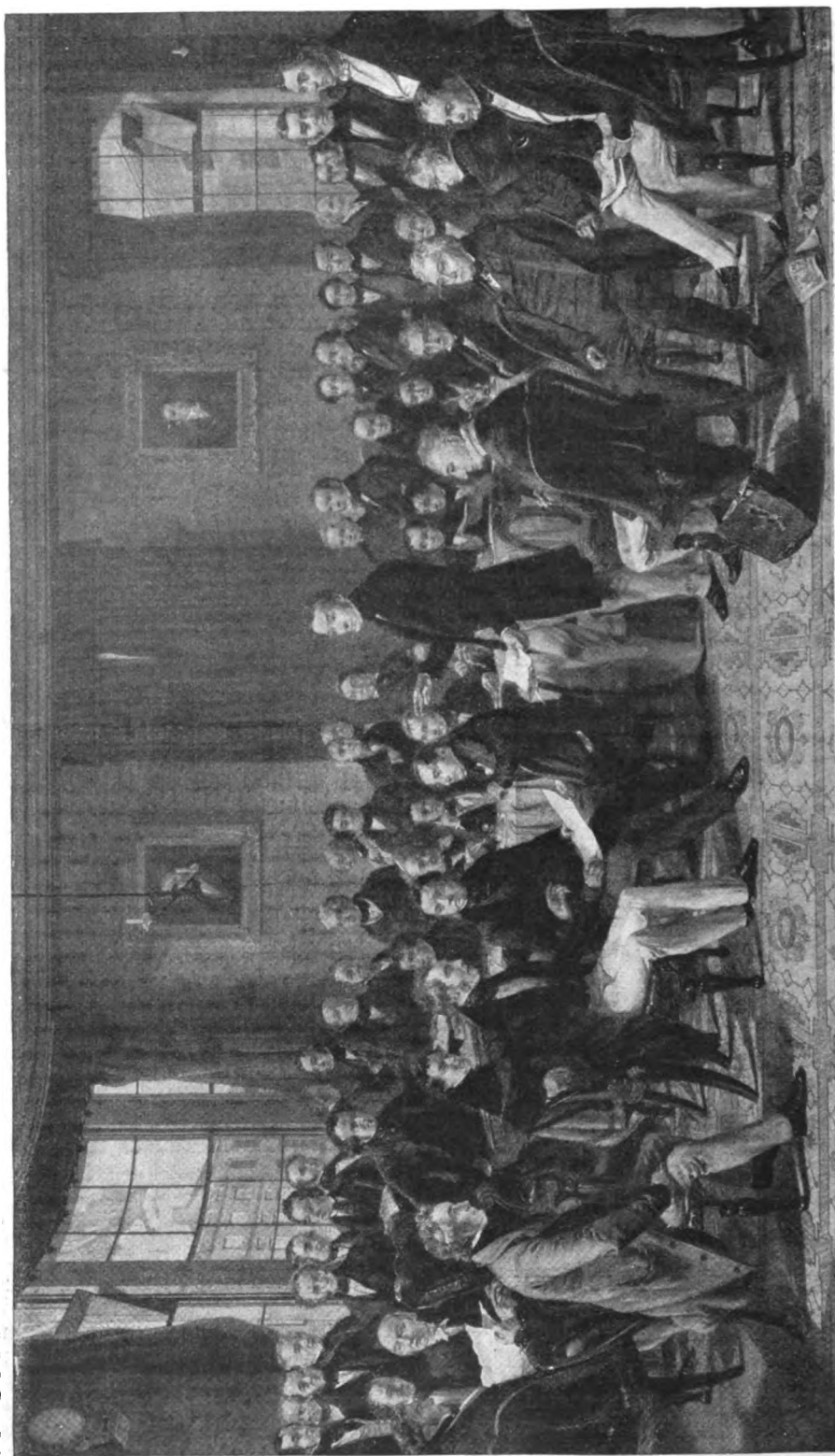
MODEL OF THE DOWSON GAS PLANT

work it was essential to wash the gas and condense the tar, and still leave it strong enough to fire well and give good results in the engine. So Mr. Dowson first enriched his gas with oxygen by injecting steam into a furnace as well as air, and in this way he obtained a strong gas which passed through a washer and a condenser on its way to the cylinder of the gas-engine. Having made a suitable plant, in 1879 he tried a small Otto engine with it, with admirable results.

Some years afterwards a French engineer tried to improve upon the Dowson gas-producer plant, but failed. Mr. Dowson then took the matter up, and succeeded in constructing a more simple gas-generator for

JOSEPH EMERSON DOWSON
Photograph by Maull & Fox

working with the gas-engine. This was the famous suction plant, in which the suction stroke of the engine creates a draught in the gas-generator sufficient to produce just the quantity of gas the engine needs for each working stroke. No gas-holder is necessary, and no fan for blowing in the steam and air. The steam is generally a by-product formed out of the water used in cooling the generating furnace. The Dowson plant and its various successors represent the most important advance in the production of working power since the invention of the modern steam-engine by Watt. The combined mechanism of a producer and a gas-engine is the most efficient way of extracting work out of various kinds of coal. On it are largely based the various schemes for turning coal into electrical power at the pit-mouth, for all industrial and domestic purposes. In other words, Mr. J. E. Dowson is one of the founders of the coming electric age in our civilisation. The Institution of Civil Engineers has awarded him the Telford gold medal and premium; the Institution of Electrical Engineers has also awarded him a premium, and his magnificent work has been honourably recognised by other scientific authorities.

A GATHERING OF THE MEN WHO FOUGHT FOR UNTAXED BREAD

COBDEN ADDRESSING THE NEWLY FORMED ANTI-CORN-LAW LEAGUE AT MANCHESTER, AS PICTURED BY J. R. HERBERT, R.A.

PIONEERS

FRANCES MARY BUSS
Pioneer of Education for Girls

FRANCES MARY BUSS, the pioneer of secondary education for girls, was born on August 16, 1827, her family being Londoners. Bred in an artistic circle, she early developed intellectual tastes. Home circumstances made her an experimental teacher at fourteen, and in the schoolroom she spent the rest of her working life. During her girlhood middle-class education was glaringly deficient. Showy "accomplishments" served as substitutes for knowledge intelligently sought. That boys and girls should be educated to the same level was regarded as preposterous. Early Victorian respectability was shocked at the thought of girls learning Latin, or mathematics, or, above all, science. Colleges for women were openly derided, and the "sweet girl-graduate" was regarded as the creature of a poet's humorous fancy. These notions began to be dissipated after the evidence which was given before the Schools Inquiry Commission, in 1864, by Miss Buss and other distinguished pioneers of higher education for girls. The pitiable ignorance of girls in the middle grades of society was exposed before the Commission, and measures were taken for enabling girls to participate to some extent in educational endowments. Within ten years of the coming into operation of the Endowed Schools Act, Miss Buss was able to count forty-five new endowed schools for girls, some with accommodation for hundreds. An onward step was taken in 1863, when Cambridge University allowed girls to take the Local Examination as an experiment. Behind this movement, both as a stimulator of public opinion and as a teacher, Miss Buss took an influential part. Her scholars did well, and she urged that, with better organisation of the examinations, women would take rank as students with men—a forecast that was amply fulfilled.

Her own education had been chiefly obtained at evening classes held at Queen's College, and when, at the age of twenty-three, she obtained the diploma of the college, she at once became the head-mistress of a new school in Camden Street. After that the keynote of her lifelong endeavours was struck in the exclamation: "I would have girls trained to match their brothers!" When her school had become remarkably successful, she unselfishly relinquished her control of it, and, as a matter of general policy, converted it into a public foundation.

The North London Collegiate School, as it was now called, was not only unique, but gave the start to a new era in girls' education, and became a model for secondary schools in all parts of England and other countries. The school was equipped with all the necessary appliances for teaching the sciences which had been regarded as a preserve for men.

Miss Buss was keenly sensitive on the question of training women teachers to teach, and helped to build up the network of schools, colleges, and university departments which now meets in this respect the needs of the nation. She lived to see the almost complete triumph of her ideas after fifty years of work, and stands the representative figure in the emancipation of the intellect of women from cramping prejudice.

She was a fascinating teacher, a motherly adviser of girls, an idolised head of the pioneer girls' high school. She died on the eve of Christmas Day, 1894.

SIR EDWIN CHADWICK
The Founder of Public Hygiene in England

Edwin Chadwick, the man who founded the English system of Public Health, was born at Longsight, near Manchester, on January 24, 1800. After an education for the law, he drifted from the Bar to the studies of a publicist, wrote articles for the

newspapers and essays for the "Westminster Review," then the organ of advanced thought, and became associated with Jeremy Bentham as a literary assistant—work that was acknowledged substantially in Bentham's will.

When, in 1832, a Royal Commission of inquiry into the operations of the Poor Law was formed, Chadwick was engaged as one of the assistant commissioners making the inquiries, and he showed such interest, energy, and intelligence in his work that he was put on the Commission itself next year, and eventually took the principal part in preparing the General Report which led to the introduction of the reformed Poor Law.

FRANCES MARY BUSS
Photograph by E. J. Lambert

Chadwick was a firm disbeliever in the public administration of small areas. He saw, under the parish system, the evil of narrow views and a pursuit of personal, in preference to public, interests. Combating that tendency, he helped to make the Poor Law union the unit of relief administration, and he championed staunchly the idea of central national control, as a means of spreading more intelligent methods than the strictly rural mind could adopt. The value of his public work depended in a large degree upon his hold on this principle, but it also added to the difficulties of his life, and at one period led to a serious defeat.

In 1833 Chadwick was included in the Commission appointed to inquire into the hours and conditions of labour of factory children, and the curtailment of the children's hours of work; and the appointment of factory inspectors by a central authority was among the results of the report he drew up. Other reforms that were realised long afterwards, such as the recognition of employers' liability for accidents, were suggested in this report.

When, in 1834, the Poor Law Commission was appointed, Chadwick became its secretary. His experience in connection with Poor Law work revealed to him the imperative nature of the demand for public sanitation, and his was the influence which caused the first Sanitary Commission to be appointed, in 1839. He also introduced the official registration of the causes of death. In 1842 he published, as a consequence of work done jointly with Dr. Southwood Smith, a terrible report on "The Sanitary Condition of the Labouring Population." In it he pointed out that the probability of life for an English working man was thirteen years lower than the probability of life for a Swede. These investigations led to the passing of the Public Health Act of 1848, and Chadwick became one of the Commissioners on the first national Board of Health. The Board had a stormy career, and after a keen fight in Parliament was dissolved in 1854, and the Local Government Board came into being in substitution for it, the great initiator of Poor Law and sanitary reform being retired on a pension of a thousand a year.

There is no doubt Chadwick was not an easy man to work with, unless his colleagues really believed in going straight for the removal of evils. He believed in action, prompt and drastic. In a singularly complete manner his ideas have, since his official day, been carried out with enormous public advantage, but the local authorities were not ready for co-operation with sanitary science in the fourth and fifth decades of the nineteenth century, and they were intensely resentful of central control or dictation. The Acts passed to help the country to become healthy were permissive, not compulsory, and the most backward districts were the least ready to adopt such Acts. Many local bodies united to check all the new-fangled ways of doing the public good which were summed up in the proposals and demands of Edwin Chadwick; and, in the end, a complaisant Government moved him out of the way while he was still in the prime of life. But he had laid, deep and sure, the foundations of an almost incredible improvement in the public health.

After his retirement from the public service, Chadwick did a quarter of a century of additional work as a private citizen intensely interested in a wide variety of public questions. He helped to start the system of examination for appointment to the public services. Public control of railways, like highways, for the public benefit was one of his ideas that has not even yet fructified.

Foreign societies of medicine and hygiene offered him honours, and he was President of the Economic Section of the British Association and the Public Health Section of the Social Science Association. In 1889, when he was verging on four-score years and ten, he was knighted. He died at East Sheen, July 6, 1890; and his Life has been written by Sir Benjamin Ward Richardson, with a sympathetic insight that is a posthumous compensation for the contumely poured on him in his early life by vindictive ignorance.

Sir Edwin Chadwick was a genuine pioneer—clear-sighted, sane, yet ideal, fearless, possessed by his schemes, but he also had the disadvantage of his strength, and was unaccommodating and always ready for a fight. The final count to his credit is that he held so firmly the friendship of the men who worked under him officially and succeeded him that they cleared his memory, and re-endowed him finally with the public credit his opponents, with a strange short-sightedness, had tried to snatch from him.

THOMAS CLARKSON
Emancipator of the Slaves

Thomas Clarkson, friend and emancipator of slaves, was born at Wisbeach on March 28, 1760. His father, a clergyman, was master of Wisbeach Free Grammar School, and wished that his son should enter the Church. Thomas, admitted to St. Paul's School, London, obtained, five years later, one of the Exhibitions, which took him to St. John's College, Cambridge, where, at the end of three years, he graduated. At this time slave-owning was considered quite a matter of course, reflecting no dishonour upon those engaged in the trade. Many illustrious houses engrossed in commercial ventures were enriched by the proceeds of the capture and sale of slaves. The morality of the traffic had never been publicly challenged. But the whole question was just now agitating the minds of a generous, right-seeing few. One was Dr. Peckhard, Vice-Chancellor of the University, who, after a powerful sermon against the unholy commerce, chose for the theme of an essay to be written in Latin by Bachelors of Arts, "Is it right to make slaves of others against their will?"

Clarkson, who was twenty-five at the time, resolved to compete, not because he had any knowledge of, or interest in, the subject, but because he thought he stood as good a chance as any other man of carrying off the prize. He laboured with all his strength to prepare his data, and was speedily convinced that his answer to the query must be in the affirmative. He read all that he could upon the subject; he interviewed people who from personal knowledge could tell him of its details; and

THOMAS CLARKSON

presently, from a mere writer of an examination paper, he found himself an ardent advocate of the cause which his paper was to expound.

"No person can tell," he afterwards declared, "the severe trial which the writing of it proved to me. I had expected pleasure from the invention of the arguments, from the arrangement of them, from the putting of them together, and from the thought, in the interim, that I was engaged in an innocent contest for literary honours. But all my pleasure was damped by the facts which were now continually before me. It was but one gloomy subject from morning to night. In the daytime I was uneasy, in the night I had little rest;

I sometimes never closed my eyelids for grief, and I always slept with a candle in my room that I might rise out of bed and put down such thoughts as might occur to me in the night, if I judged them valuable, conceiving that no arguments of any moment should be lost in so great a cause."

The Clarkson essay gained the prize, but its author felt that he could not let the matter rest there. He translated his essay into English and published it. The pamphlet brought him introductions to Granville Sharp—who caused the liberation of the last slave on English soil—and others who were labouring at the question. Chief of these was William Wilberforce. It is a fact of which the Society of Friends has every reason to be proud that an important committee of twelve men now formed to put down slavery comprised only three men who were not Quakers. Of these Clarkson was one. Although he had been ordained a deacon, he relinquished all thought of entering the Church, and devoted himself entirely to his anti-slavery crusade. He travelled from end to end of the land again and again, stirring the public mind against the abominations of the traffic in which English merchants, planters, and private gentlemen were engaged.

The story of that struggle for the redemption of the African slaves need not be recapitulated. Clarkson toiled night and day in the work, wore himself out, brought himself to poverty, broke down, and had to rest for seven years; then returned and helped to carry the day. He had done a dozen men's work in endeavouring to convert France to the doctrine of "liberty, equality, and fraternity" for black men as well as for white; and he now waited upon the Emperor of Russia with a view to securing his adhesion to a world-wide movement for the suppression of slavery. His last battles were fought on behalf of the slaves of the West Indies, but it was not until 1833 that the Emancipation Act was passed which brought freedom to 800,000 slaves, and gave £20,000,000 in compensation. Although broken in health by his long-continued exertions, Clarkson lingered on to the age of eighty-six, and had the satisfaction of knowing that whereas in his youth even in England there were bondmen from many lands, at last he could say that nowhere under the Union Jack was there a single slave. He died at Playford, near Ipswich, on September 26, 1846. The roll of private citizens who did public work contains no name more honoured.

RICHARD COBDEN

The Story of a Revolution in Economics

Richard Cobden, who more than any man brought into practical life in England the theory of free interchange of products between country and country, as was suggested by Adam Smith, was born on June 3, 1804, on a farm near Midhurst. His father, a man of gentle disposition, was quite incapable in matters of business. A fall in prices involved him in ruin, but, relatives coming to the rescue of the children, Richard was sent to a Yorkshire school, where he spent five unhappy years—"ill-fed, ill-taught, ill-used."

On his release he became a clerk in an uncle's London warehouse, and at twenty-one was promoted to the position of commercial traveller, a vocation that satisfied his craving to familiarise himself with men and affairs. His journeys provided endless opportunities for the exercise of tact, urbanity, and readiness of speech. He was, in fact, unconsciously in training for a statesman.

Then he began business on his own account, and thrived amazingly. But amassing wealth was not Cobden's ambition. He had a passion for accumulating information that could be turned to practical account. Apart from the smattering of knowledge obtained at school, he was a self-taught man. For languages and history he appears to have had a special liking. He was steeped in the science of political economy, and may fairly be regarded as the first man to translate some of the economic principles of Adam Smith into large, serviceable realities.

Professor Thorold Rogers has said: "If exact and careful knowledge of history constitutes learning, Cobden was, during the years of his political career, the most learned speaker in the House." His acquaintance with general literature was surprisingly wide, and the rare merit of his literary style has won the admiration of Lord Morley (his biographer), who describes him as "the master of a written style which, in boldness, freedom, correctness, and persuasive moderation was not surpassed by any man then living."

A lover of travel and an alert observer, he amplified his education by visits to the Continent and America; and in 1835 appeared his pamphlet "England, Ireland, and America," followed in 1836 by one on Russia. These pamphlets, written before Cobden had taken any serious part in political agitation, may be said to embody

his scientific views on legislation and government. Though he was essentially a practical man, whose interests were bound up with manufactures and trade, " he never ceased " (as Morley declares) " to be the preacher of a philosophy of civilisation."

His main argument centres upon the material and national advantages of an unfettered trade—freedom to " buy in the cheapest market and sell in the dearest." Irrational systems of government, acting on industry, diminished wealth and injured the general well-being. The well-being of the masses was a barrier, he contended, against discontent, disorder, and revolution. As social happiness and national stability depended on the right use of economic resources, he came to the conclusion, in his own words, that " at certain periods in the history of a nation it becomes necessary to review the principles of domestic policy for the purpose of adapting the government to the changing and improving conditions of its people."

The kernel of his theory of " non-intervention " lies in his statement of the principle " that no Government has the right to plunge its people into hostilities except in defence of their own national honour or interests."

At this time the country was plunged in distress. Paupers and criminals abounded, and sullen and idle workmen were joining Chartist or Socialist organisations. Thoughtful politicians were canvassing methods for easing the situation. Cobden desired to try the experiment of cheap food for the people. In his first pamphlet he had asserted that the Repeal of the Corn Laws was absolutely necessary for the welfare of the State, and he now decided to devote his public life to accomplishing that object. He set out on the career which was to make his name for ever famous.

In 1837 he stood as Parliamentary candidate for Stockport, but lost the election on the question of factory legislation. The next year seven men met in a Manchester hotel, and formed an association which was afterwards merged in the famous Anti-Corn Law League. Cobden was soon the leader and prophet of the movement. He won his spurs in the Manchester Chamber of Commerce, where he rallied the waverers and carried a motion in favour of petitioning Parliament for repeal of the corn duty.

Cobden had already outlined a programme of work for the League. Early in 1839 what proved to be a long and strenuous campaign was begun. " For five years," said Mr. Bright afterwards, "we devoted ourselves without stint. Every working hour was almost given up to the discussion and to the movement " connected with the great crusade. Manufacturers and merchants were lavish in their subscriptions ; a staff of lecturers set out on an economic mission, and every elector in the kingdom received a budget of tracts. Cobden and his companions of the so-called " Manchester School " were derided, for the Corn Laws were thought to be as impregnable as the monarchy. The middle classes quickly accepted the new doctrines, and even the

RICHARD COBDEN
From the portrait by Lowes Dickinson

farmers, though at first suspicious and unfriendly, yielded to the patient and powerful arguments of the agitators. But feeling in the country fluctuated with the harvests and the state of the labour market, and Parliament must be conquered.

Cobden, returned for Stockport at the election of 1841, immediately resumed the struggle from his seat within the House. For five years he and his friends Mr. Bright and Mr. Charles Villiers stood courageously to their task. The Prime Minister (Sir Robert Peel), whose views had been gradually changing on the question, at last admitted that Cobden's arguments were unanswerable. A wet harvest, and the news of a potato famine in Ireland, added to the Minister's difficulties, and he finally capitulated to conviction and circumstances. The " Apostle

of Free Trade" had won, and a measure was introduced and passed in 1846 for the abolition of the Corn Laws in three years.

Poverty and broken health were the outcome of Cobden's tireless exertions. A welcome testimonial of nearly £80,000 repaired his fortune, and a prolonged holiday tour on the Continent fitted him afresh for Parliamentary activities. His subsequent condemnation of the Crimean War made him for a while extremely unpopular in the country; yet, in 1859, his old foe Lord Palmerston offered him a seat in the Cabinet, which Cobden felt compelled to decline on the ground of his former irreconcileable attitude towards the Prime Minister's foreign policy. An outlet for his particular genius was, however, found. He was empowered to act as her Majesty's plenipotentiary in negotiating a commercial treaty with France.

This was the second great work of his political life. By skilful and patient argument, genial tact, and marvellous knowledge of details, he gained the confidence and assent of Napoleon III. and his Ministers. The treaty was signed, the tariff settled (1860), and an enormous expansion of commerce between the two countries ensued. The English centres of industry hailed the agreement with delight. In addition to this achievement, Cobden did the public a valuable service in securing the abolition of the passport system, and in arranging more convenient postal facilities with France.

Cobden was a man of great charm, good-natured, buoyant, dauntless. "The manliest and gentlest spirit that ever quitted or tenanted human form," said his faithful friend John Bright.

He was a trenchant speaker, unsurpassed in lucidity and persuasiveness; and, as a politician, had a singularly honourable and unselfish record. Though some of his forecasts have not come true, through a too generous estimate of the political and economic wisdom of the Continental world, the expansion of his policy has given his own country a position in trade without parallel in the story of mankind.

He died in London on April 2, 1865, and was buried at Lavington, in Sussex.

JOHN COLET

The Pioneer of Grammar Schools in England

John Colet, the friend of Erasmus and Sir Thomas More, one of the most striking figures of the classical renaissance in England, and the pioneer of grammar school education, was born in London in 1466. He was the son of Sir Henry Colet, a rich City knight who had twice been Lord Mayor. After seven years at Magdalen College, Oxford, where his special studies were logic and philosophy, Colet went to Paris and thence to Italy, and, like other English scholars of his time, became enamoured of the newly recovered Greek learning. It is not unlikely that in Italy he caught some of the moral fervour of Savonarola.

Returning to England in 1497, he took Orders, and after several preferments was made Dean of St. Paul's. Colet did not concern himself with traditional theology. His sermons were of the best modern type, simple, intelligible, stripped of mysticism and dogma, and based upon the life and sayings of Christ Himself. So he infused a new spirit into the cathedral services.

Colet's views of the reformation of the Church were prudent and penetrating. Reformation was necessary, but the bishops should supervise their sees more vigilantly. They should set a virtuous example to their clergy, and to the laity. The luxury and idleness of the clergy were unsparingly condemned. These opinions roused much indignation, and his own bishop brought against him a charge of heresy, but Archbishop Warham and the King were his friends. Henry quaintly remarked: "Let every man favour his own doctor, but this man is the doctor for me."

Colet treated the Scriptures from the historical standpoint, a method as daring then as it was novel. He was, in fact, in this field of thought, many generations ahead of his own day. Amongst the delighted Oxford men who flocked to his lectures, Erasmus and other eminent scholars were often seen.

The year 1513 found Henry VIII. in a fiercely aggressive mood, and at war with France. This event exasperated Colet, and he offered a fiery protest from the pulpit of St. Paul's, declaring that "an unjust peace is better than the justest war." The Renaissance had generated a spirit of healthy criticism; even kings must not lightly hinder the progress of the bright hopes awakened by the new learning.

But another Pope succeeded, and calm again was restored. Colet seized the opportunity to begin that remarkable educational reform by which he is now best remembered.

The Dean inherited an ample fortune, and he determined to devote this largely to the building and endowment of a school

THE STATUE OF JOHN COLET, WHICH STANDS IN FRONT OF ST. PAUL'S SCHOOL, LONDON

where boys could receive a sound education in Latin and Greek. He was absorbed in this splendid project, which was completed in 1512. An estate in Buckinghamshire was transferred to the Mercers' Company to provide for the teachers' salaries, and—an important innovation—the control of the school was vested in the married laymen of that corporation. William Lily was appointed the first head-master, and much thought was given to the production of a suitable Latin grammar, Colet himself editing the work, which remained in use for two centuries or more. He drew up the regulations of the school, and it became a model for others in curriculum, methods, and purpose. He expounded the science of teaching to his "well-beloved masters," and recommended that pupils should not be hampered with difficult rules at the start, but that the study of good authors should be encouraged, every word

and sentence being observed; that the boys should be taught to converse in pure Latin; and that by "busy imitation with tongue and pen" they would gain more than by tradition, rules, and precepts. Colet's work in education had a vivifying effect throughout the land, and more than any other single influence helped to establish the grammar school system that is now being happily merged into a national scheme of secondary education, under public control.

The Dean was a man of commanding personality, noble in his life, unspoilt by his dignities. St. Paul's School, with its magnificent achievements, remains his lasting monument. He died on September 16, 1519.

JOHN AMOS COMENIUS
The Man who Made Learning Easy

John Amos Comenius, the great educational reformer of the seventeenth century, was born at Nivnic, in Moravia, on March 28, 1592. Comenius is the Latin form of the name Komenski. At sixteen Comenius was smitten with a love of learning, and was eager even then to devise simpler and cheaper methods for promoting the education of the young. He described the schools he knew as "places where a hatred of books and literature is contracted, and minds are fed on words."

JOHN AMOS COMENIUS

After a brief experience as a schoolmaster he became the pastor of the Moravian church at Fulneck. The battle of Prague, in 1621, was followed by the capture and sack of Fulneck, and Comenius lost his manuscripts in the wreck of his home. His troubles were trebled by the loss of his wife and his only child. Persecution forced him to flee into Poland, and he was never permitted to return to his native land.

What his country lost the world gained. The exile settled at Lissa, where he made a deep study of the works of the educational thinkers, and carefully digested the philosophy of Lord Bacon, of whom he was an ardent disciple. A critical examination of Bacon's works led him to write his "Didactica Magna," which, as he naïvely explains, "shows the art of readily and solidly teaching all men all things."

In 1631 he published the book which immediately established his reputation. It was translated into many European and Asiatic languages. This was the "Janua Linguarum Reserata"—"Gate of Tongues Unlocked."

Parliament invited Comenius over to England in the interests of education, but the plan failed owing to the threatened outbreak of civil war. At this juncture a rich Dutch merchant offered him a home and terms which would enable him to prosecute his plans. By this agreement he was to write a book on education with a special bearing on the teaching of languages.

The range of his sympathies stretched beyond his scholastic work. As bishop of the religious body with which he was associated, he was often occupied in controversies, and with the affairs of his Church. He was freed from an uncongenial relationship with his Dutch patron on the death of the senior bishop, to whose dignity he succeeded. This involved his departure from Elbing, where he had lived eight years. He fixed his home at Leszna, but left it in answer to a request that he should reform the schools in Transylvania.

He founded a model school at Saros-Patak, and in intervals of leisure wrote his most famous book, the "Orbis Pictus," an abridgment of the "Janua," but accompanied with pictures, the first picture-book, in fact, that ever brought gladness into a schoolroom. Back at Leszna, he was again the victim of misfortune; the Poles, enraged by the victorious invasion of the Swedish king, whom Comenius had indiscreetly congratulated, looted his house and utterly destroyed his most precious manuscripts. He eventually found a quiet refuge in Holland, where, with the help of a wealthy friend, he published a complete folio edition of his writings on education.

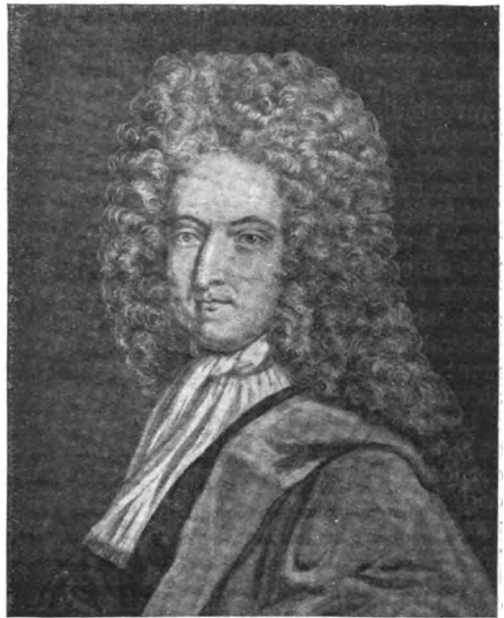
Those writings are pregnant with suggestion, and of the utmost value to the student. The "Great Didactic" is a treasury of pedagogic science, overflowing with ideas wisely and pithily expressed. Comenius lays much stress on the necessity for following the methods of Nature. The child should be taught to link words with things, and in this Comenius anticipated that branch of elementary science now known as "Nature study." Education should come, in due order, through the senses, the memory, and the intellect. In teaching a foreign language abstract rules should be ignored, and the pupil should be put into direct touch with an author's work.

The "School of Infancy" is an early contribution to the literature of the Kindergarten. The infant mind should lie fallow, absorbing the influences of its physical environment until ready for the processes of culture. It is able to imbibe science by observation, and unconsciously but surely acquires, in the home and its surroundings, an inkling of botany, geography, astronomy, arithmetic, and even of logic and politics. His Latin primer, the "Janua," affords a graphic exhibition of his inductive method of teaching a language. On each page are parallel columns of Latin phrases and the vernacular equivalents; these refer to such subjects as the Earth, Man, the Home, the State, the Mind, and constitute a concise encyclopædia of knowledge, as well as supplying a vocabulary of familiar words, with a skilful interweaving of the chief grammatical difficulties that may occur.

Comenius was also the first great educator to plan a scheme of instruction extending from infancy to manhood. His division of schools into "mother," vernacular, Latin, and university correspond, very nearly, with the infant, primary, secondary, and higher schools of the present day. Raumer avers that "the influence of Comenius on subsequent thinkers and workers in education is incalculable." Compayré claims that he applied to pedagogy, with remarkable insight, the principles of modern logic; "that he was indeed the Bacon of modern education." Comenius died at Naarden on November 15, 1671.

DANIEL DEFOE

An Intellectual Forerunner of Modern Progress

Daniel Defoe, famous as the author of an immortal novel, but seldom remembered for his original and ingenious essays on social science, was born in London, in the parish of St. Giles, Cripplegate. His father, James Foe, was a prosperous butcher. The name Defoe, assumed by the son, was probably a play upon his signature, D. Foe. He joined the standard of the Duke of Monmouth, missed being sentenced by Judge Jeffries, and in 1688 was in the crowd that welcomed William III. His career was checkered with contrasts. At one in principles with the Dissenters, he alienated their goodwill by condemning their inconsistent lapses into conformity. Possessing the keenest instincts for business, his commercial ventures unfortunately led him to bankruptcy. A vehement but vacillating politician, equally dexterous as the secret agent of Harley or Godolphin, he

DANIEL DEFOE

perplexed the Whigs as much as he exasperated the Tories. But at last, when broken in health and weary of politics, he achieved a series of literary triumphs at an age when many of the greatest writers begin to fail in freshness and power.

His first noteworthy book was an "Essay on Projects," published in 1697. It teems with ideas scientifically interesting, strikingly practical, often whimsically elaborated, and far in advance of his own times. In this work Defoe writes with much sagacity on the science of banking. The system of banking, as it is now understood, had only been recently introduced into England, and was practised chiefly, and not always honourably, by the goldsmiths

of London. Defoe sarcastically refers to "their most delicious trade of making advantage of the necessities of the merchant in extravagant discounts, and premiums for advance of money." The Bank of England was established about the time (1694) that he was writing the essay. After criticising its limited capital, and the consequent abridgment of its usefulness, he makes several excellent suggestions as to various branches of financial business it could engage in. Among others, it might start an office for inland exchanges, which would, he affirmed, dispose of all the current notions and proposals respecting county banks. This office would appoint a cashier in the capital towns of every county, and through the channel of the Royal Bank money transactions with every large town could be conducted at a small commission of ½ per cent. Highway robbery would be prevented, and the country saved from ruinous loss. But he admits that independent county banks would be of greater value, and he clearly describes the sort of institution he would set up. It was indeed what is now called a joint-stock bank, with this difference—he would plant it in such towns as were governed by a corporation; and while the stock should be open to general subscription, the deeds of settlement would be vested in the mayor and aldermen, the mayor always being a director.

Here would appear to be the germ not only of modern county banks, but of the corporation stocks so much favoured today. It was not until 1826 that legislation removed the restriction on note issues, and so encouraged the formation of joint-stock banking companies. Defoe was the first to originate the idea of savings banks for the comparatively poor working classes, but not till exactly a century afterwards did Jeremy Bentham revive the suggestion, under the name of "Frugality Banks," and in 1799 the Rev. Joseph Smith put it in action at Wendover.

In another essay on "Highways," Defoe anticipated by more than 200 years the appointment of a Road Board under the Development Act of 1910. After showing that the Romans applied the science of government to purposes of national convenience, he went on to prove that the science of road-making might immediately be used in devising plans for the abolition of impassable highways. An Act of Parliament might grant a charter to a company undertaking to make and maintain the public roads. The company must be armed with powers to enclose, or encroach into, lands on the line of route, to fell trees, and to do whatever was necessary, provided that the owners were previously satisfied, compensation being adjusted by Government arbitrators. Taking Middlesex as an illustration, he gives with amusing precision the cost of the enterprise for that county, and avers that, backed by the authority of Parliament, a national undertaking was perfectly feasible, and of enormous advantage to travellers and traffic.

Defoe's science of road-construction is based on Roman methods, and he supplies exact details of dimensions, drainage, paving, and materials. Other essays treat of the Higher Education of Women, of Assurance, of the Law of Bankruptcy, and of a Pension Office. In fact, in many directions Defoe was a genuine pioneer in sociological and economic directions, and the world has since been slowly realising his projects, unaware of their literary origin.

As an untiring writer of pamphlets he must be mentioned. His most famous treatise, "The Shortest Way with Dissenters," made him a popular martyr in the cause of toleration. Then, too, he started the earliest newspaper of a fearlessly independent political type. This was the "Review," which continued in uninterrupted circulation from 1704 to 1713.

His novels, including the inimitable "Robinson Crusoe," and his supposititious histories, so vivid that they still leave us in doubt as to their reality, can only be mentioned here.

Defoe died in Moorfields, on April 26, 1731, and was buried in the Dissenters' historic graveyard in Bunhill Fields.

WILLIAM HENRY DINES
The Brilliant Explorer of the Upper Air

William Henry Dines is the son of Mr. G. Dines, of Horsham. Born in 1865, he was educated at Windlesham and Corpus Christi College, Cambridge. In the early part of his career he was a tutor, but he gave his leisure to scientific work. The study of weather specially attracted him, and in 1879 he was able to show that for North-Western Europe the suggestion of an association between a high barometer and cold weather in winter was false. But important as were these observations, it is not to them that Mr. Dines owes his fame. He is the successor to Glaisher, the balloonist, who at great peril added to our knowledge of the higher levels of air. There was a long interval between Glaisher and his

more scientific successor. For it was not until 1902 that Mr. Dines began to send up box-kites and pilot balloons and self-registering balloons. He started his work on the West Coast of Scotland, and in 1905 continued it at Oxshott, fifteen miles south-west of London, and he is now exploring the air from Pyrton Hill, in Oxfordshire.

Mr. Dines uses three kinds of kites, and several kinds of balloons. There is a storm-kite that can rise in a wind at forty miles an hour. This is 7 feet high and 2½ feet broad, with curious rounded sails that let some of the force of the wind escape. There is a larger kite, 9 feet high, for use in light wind, and a standard kite similar in shape but with tapering sails. The advantage of a kite is that it can be kept at a practically constant level for some time, and, being well ventilated, it is more reliable than a balloon for registering the temperature and humidity of the air. Attached to each kite is a meteorograph of Mr. Dines's invention. It consists of a wind measurer, a thermometer, a clock, and a barometer, with recording pens that write on a cardboard disc. It records automatically the moisture, the atmospheric pressure, the temperature, and the wind velocity.

The self-registering balloons ascend much higher than the kites. They are small things, about 39 inches in diameter, and with just a little more lifting power than is required to raise a meteorograph. With these balloons Mr. Dines has made some hundreds of observations, up to a height of nine miles or so. About sixty out of every hundred of the balloons sent up are recovered. In the calm weather of summer they often fall among the standing corn, and the instrument is completely shattered by the mowing-machine. In the high winds of winter, when the ground is bare, more records are obtained.

Mr. Dines is particularly interested in the so-called "holes in the air" of which aviators complain; for these interfere with the stability of his kites, and he thinks if the problem of the stability of a kite could be completely elucidated that of the stability of the aeroplane would follow. All kites can fly in a steady wind, but none of them will remain stable with a wind blowing at fifty miles an hour at a height of 1500 feet.

Some of the most important of Mr. Dines's researches have been carried out at a height of about 5½ miles. The conditions of the weather that prevail at this altitude govern the conditions of the weather on the surface of the earth. Mr. Dines has found that the pressure in the layers of air at a little more than 4½ miles is the dominant factor in the distribution of pressure and temperature. He, however, disagrees with some authorities in regard to the part that the wind plays at that height. In his opinion the strong currents of air blowing over the upper atmosphere have little or nothing to do with the matter. It is the upright columns of rising or falling air which produce the changes at the surface of the earth. These rising or falling columns seem to be the holes in the air that trouble aviators; they are the direct result of variations in the pressure of the atmosphere.

The meaning of all this is that the weather forecasters of the future will require regular reports of the state of the air at different points at a height of 5½ miles. Unfortunately, it is only on rare occasions at present that we can ascertain the rate and direction of the wind at great heights; but it is hoped that pilots of balloons and airships, and aviators generally, will be supplied with detailed information as to the air currents and weather conditions likely to be encountered a few hours ahead.

SIR HENRY DOULTON

The Man who Revolutionised Drainage

Henry Doulton was born at Vauxhall, London, on July 24, 1820. His father was a potter in a small way of business, but gave the lad the best education available within the time at his disposal, which was not excessive, seeing that the youth, who was to confer lasting renown upon the family name, entered the business when fifteen years of age. Pottery in England had at that time reached a very low ebb. The old artistic methods had been gradually abandoned without worthy processes to succeed them. The youngster, who was at once put to the practical side of the trade, began his career as a learner at the ordinary potters' wheel, and for many years was engrossed in the toil and drudgery of the journeyman's task. The firm began to produce what are known as stoneware jugs and bottles, and from this ware Doulton gained a fruitful idea.

During the first half of the nineteenth century London was a terribly insanitary city. Drainage was conducted by means of old-fashioned, flat-bottomed brick gulleys, through the gaps in which sewage percolated into the soil, there to multiply deadly bacilli and pave the way for fatal epidemics.

Buckingham Palace was in so dangerous a condition that a Commission appointed to inquire into the matter dared not present its report to Parliament. Cholera swept over the city in 1848, and typhoid invaded the precincts of Westminster Abbey, where 400 cubic yards of foul matter were removed from the branches of the ancient sewers. Dean Buckland preached a sermon in the Abbey which rang through England, "Wash you, make you clean." He advocated the uprooting of the old, defective sewers, and the installation of impervious pipes.

Doulton had anticipated him. His instinct had shown him that the demand for better sanitation which was sweeping over the country could be met only by the provision of stoneware pipes for which the aroused Dean was now calling. Two years before Buckland preached his sermon, Doulton had opened premises of his own devoted entirely to the manufacture of pipes. Buckland took them up with a will, but there were few others to follow.

Builders and experts were against the principle, and for some time fewer pipes were sold in England than in Paris, where the reforming zeal of Napoleon III., guided by one or two English men of science, was at work. But little by little the success of the Doulton product became established; and when the pipes were generally adopted a revolution in sanitary science spread from London throughout Great Britain and the British Empire. It made Doulton a rich man, and afforded him the means for carrying out a second scheme which was far dearer to his heart.

This was a renaissance of English art pottery. Beginning in a small way, he produced articles which were not merely useful but beautiful. The idea was revolutionary for England, for it had become quite the habit to look to the English potter only for articles of everyday use, and to buy from abroad all decorative ware. But Doulton trained young men and women in the finer details of the work; he trained artists to design for him, and to paint and colour for him.

Under his fostering care a huge reform was effected. It did not stop at the betterment of china. It extended to wares of all kinds associated with the calling of the potter—stoneware, silicon, impasto, terra-cotta, faience, etc.

Since then Doulton wares in a hundred forms and materials and designs and shades have been set up throughout the civilised world. The Doulton factory at Lambeth, the most artistic industrial establishment of its character in London, is of Doulton ware; the attractive Russell Hotel, among others, is faced with Doulton bricks, and scores of fountains and other decorative erections in public places are from the same source.

Doulton, who received the Albert medal and was made a Chevalier of the Legion of Honour, was knighted "for important service rendered to technical education, especially to technical education for women." He died in London on November 18, 1897, master of an honoured name and of a fortune worthily gained.

ADMIRAL FITZROY

The Original British "Clerk of the Weather"

Vice-Admiral Robert Fitzroy was a man who, after an extremely varied and brilliant career, retired and did his finest work towards the end of his life. As captain of the "Beagle" on a voyage round the world, for which he engaged as naturalist a young, hesitating Cambridge man, Charles Darwin, his name is for ever associated with the grand inspiration of the author of "The Origin of Species." His "Narrative of the Voyages of the 'Adventure' and 'Beagle'" is, in part, one of the most famous books in the world, for the part in question—the third—is written by Darwin. It is the famous journal.

But besides befriending and helping Darwin, and afterwards, as Governor of New Zealand, befriending and helping the Maoris against the white settlers, Admiral Fitzroy developed the lively interest he took as a sailor in all signs of weather changes into a system of forecasting storms and sending out warnings of them. This was the beginning of the organisation of the machinery and staff of the Meteorological Office; and, as the originator of our national system of weather forecasting, Admiral Fitzroy ranks among the great and effective men of science.

No doubt much of Fitzroy's success in life was due to the fact that he was related to men of high social influence. Born on July 5, 1805, at Ampton Hall, Suffolk, he was the grandson of the third Duke of Grafton, and, on his mother's side, of the first Marquis of Londonderry. Educated at the Royal Naval College, he entered the Navy at fourteen, and became a lieutenant at nineteen. His command of the "Beagle" in the survey of the coasts of South America was obtained in 1828. Two years afterwards he returned to England, and had his ship

practically rebuilt, as the timbers had all rotted away; and on December 27, 1831, he left again for South America with Charles Darwin as his messmate.

"Slight in figure, dark, but handsome . . . he is my beau-idéal of a captain," wrote Darwin to his sister. Fitzroy was always a strict officer; he worked with remarkable energy himself, and was very severe on lazy or disobedient men. The severity of his manner was borne with because everybody on board knew that his first thought was his duty, and that he would sacrifice anything to the real welfare of the ship. But this way of handling men did not prove always successful. When, in 1843, Fitzroy was appointed Governor and Commander-in-Chief of New Zealand, his severity of manner defeated the noble object he had in view.

He came to the conclusion that the natives had rights in the land, as well as the white settlers, and he considered it his duty to look after the interests of the Maoris. To the conquering settlers he was trenchant and dictatorial; he used blunt force in a complex and difficult matter where suave persuasiveness was required. So fierce was the anger he aroused among the men of his own race that the British Government was compelled to supersede him in November, 1845. Yet his action was very fine. To stand up for justice to the Maoris, alone, with powerful interests against him in the British House of Commons, and with savagely indignant settlers surrounding him in New Zealand, needed some courage. A Tory in politics, with views on slavery that shocked Darwin, Fitzroy was nevertheless a noble man.

On his return to England, he obtained after some time the position of Superintendent of Woolwich Dockyard, and then took command of a screw frigate he had fitted out, with a view to experimenting in the application of steam power to marine purposes. But it was after he retired from active service that the great work of his life began. In 1854 a Meteorological Department of the Board of Trade was formed, and, at the suggestion of the President of the Royal Society, Fitzroy was made director of the new office. He really won the position by the care and precision with which he had studied the weather in all parts of the world.

In South America especially he had given much time and thought to the practical problems of forecasting storms. His barque-rigged "Beagle" was what was known as a "coffin" ship; she was badly designed, and liable to go suddenly under in a very bad sea. No doubt this fact had made Fitzroy keep his weather eye always open, so as to get his ship prepared against any storm. For the rest of his life he was passionately interested in storm-studies and wind-charts. He invented a cheap and useful barometer for seamen, and much improved upon the search for the law of storms begun by his American friend Commodore Maury. His "Weather Book," published in 1863, marked a considerable progress in the scientific study of meteorological conditions.

But it was as "Meteorological Statist"—the title for a time officially given to him—that Admiral Fitzroy left his mark on modern civilisation. He instituted, for the first time, the system of weather forecasting that has been developed by the later directors of our Meteorological Office. It was in February, 1861, that our first clerk of the weather issued his first warning of a storm. Next August the first general forecast of our changeable weather was prepared and published by him. All he had to work on were twenty-two morning reports and ten afternoon reports, sent from different parts of the country, together with five Continental advices. Yet on this slender information he made forecasts of the weather for two days in advance! It was a daring thing, but, owing more, perhaps, to his sailor's experience than to his scientific knowledge, he managed to do well enough in the circumstances. It must be remembered that laws of cyclones and anti-cyclones had not been fully worked out, and there were not sufficient observing stations for the pressure of the air and other weather conditions to be fully charted in the Meteorological Office.

The admiral was one of those men to whom idleness is pain. Work was his pleasure. He fell unwell through overwork, and still refused to rest. The consequence was that his mind gave way, and during this sad period of mental aberration he died by his own hand on April 30, 1865.

GEORGE FOX

The Founder of a Small, Great Sect

George Fox, the first of the Quakers, and establisher of the Society of Friends, lives in two ways—he wrote one of the autobiographies that will always be read, and he brought into being an association of men that has had a remarkable influence on the social developments of his country. He

was born at Fenny Drayton, in Leicestershire, in July, 1624, the son of a weaver, and was apprenticed to a shoemaker, wool-dealer, and farmer, in whose service he won wide esteem. From a child he was deeply pious, and while still in his teens felt himself "called" to leave his family and native place, and preach a whole-hearted surrender to the primitive Gospel of Christ, in protest against the formal religion of a Church "made with hands."

The wandering life of a preacher, on which Fox entered as a youth, continued till his death, on November 13, 1690, in his sixty-seventh year. In that period he visited all parts of Great Britain, and extended his appeals to America, the West Indies, Holland, and Germany. Almost everywhere in British lands he was persecuted, stoned, buffeted, and imprisoned, because he was an eccentric in many ways, and any eccentricity was regarded in his day as inviting a brutal reception; and also because his personal, searching, vital religion was resented by people who took their religion easily and conventionally.

Almost the whole story is told, with a quaint simplicity, in the Autobiography; but what could not be foreseen by this earnest, fearless, self-immolating man was the effect which his "testimonies," in all places, before all peoples, from the roughs of Nottingham to Oliver Cromwell, would produce. That effect was the building up of a small, compact association of members who, during the two hundred years after his death, were foremost in every good work—social, political, or religious. Even in Fox's life the Friends who had been brought into union with each other by his ministrations sometimes had a thousand of their number in prison for daring to preach and act a truly spiritual Christianity.

The fact was there was no inducement for anyone to be a Quaker who was not boldly and sturdily sincere; and this demand for individual consecration brought together a people, few but choice, who protested against war and all cruelties, who spent themselves in trying to secure such reforms as the purification of prisons, the abolition of slavery, the spread of education, a care for national health, a proper treatment of servants—and, indeed, every phase of social amelioration consistent with a religion pure and undefiled.

The oddities of George Fox, in dress, speech, and rejection of innocent conventions, are no longer perpetuated in the Society of Friends, but his insistence on individual surrender to spiritual influences, and ready acceptance of personal devotion to public service, have been perpetuated, and have had an enormous influence in moulding the bettered life of today. Again and again during the last two hundred years great reform movements have taken shape under the fostering care of a knot of Quakers, the spiritual descendants of the leather-breeched, itinerant George Fox.

FRIEDRICH WILHELM AUGUST FROEBEL
The Apostle of Teaching Through Play

Friedrich Froebel, according to Michelet, the greatest of educational reformers, was born at Oberweissbach, a village in the Thuringian Forest, on April 21, 1782. He was a baby of nine months when his mother died, and during his infancy he was heartlessly neglected by his father—the chief pastor of the district—and by the maid-servants. Left much alone, he fed on his own thoughts, pondered his natural surroundings, and, to use his own words, was occupied in "unceasing self-contemplation, self-analysis, and self-education." A child of this type is unthinkingly labelled dull. So was Froebel. Happily, his mother's brother made an opportune visit and carried him away. With this sympathetic uncle, also a pastor, he lived some years.

At fifteen he was apprenticed to a forester for two years and in the Thuringian woods he opened his heart to Nature, studied her ways, deduced general truths from his observations, and concluded that all Nature's manifestations were governed by one and the same law. A year and a half at the University of Jena was followed by many disappointments while endeavouring to settle upon a profession. The habit of self-introspection still clung to him, and he felt more than ever assured that a great human work lay in front of him.

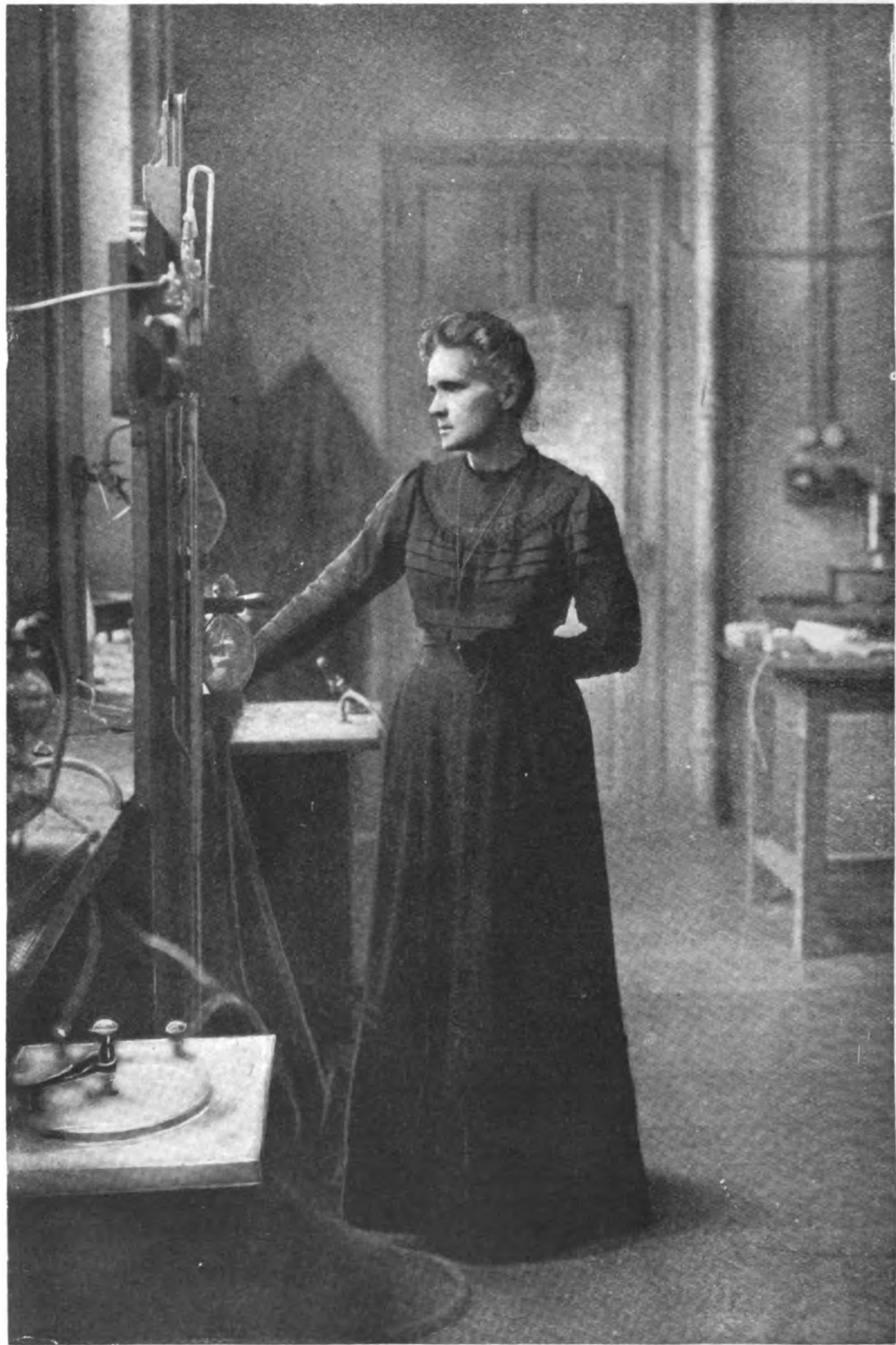
At the age of twenty-three, a friend who was head of the Frankfort model school invited him to join the staff. This he did, to his great advantage. Later, he became private tutor of three boys, whose parents were willing that he should take them away to Yverdun, in Switzerland, where the celebrated educational reformer Pestalozzi was teaching. Froebel and his boys revelled in the atmosphere of the institution over which the great teacher presided. But he noted, amidst the delightful warmth and stir of the school, a want of system, "of depth, thoroughness, extent, perseverance, and steadiness." Pestalozzi's methods were too superficial for the accomplished young

investigator. Froebel probed farther into the mind of the child, and, while gratefully accepting the older man's theories, and estimating them at their true value, he placed them on a more durable—because upon a more psychological—basis.

Leaving Yverdun, he went through certain university courses, but in 1813 he responded to the call for men to resist the invasion of Napoleon. The war brought him no honours, but it added to his circle of friends two young fellows whose admiration for him was so deep that they sacrificed everything in order to live and work with such a fervent apostle of education. The three men started a school in one of the Thuringian villages, Keilhau, and here the newest science of education was practised, not fruitlessly, but unremuneratively, until Froebel resolved to try the experiment of a branch school in Switzerland. Yet here, as elsewhere, though he inspired his teachers and pupils with his own zeal, the actual progress of his principles was not encouraging. In 1826 he had written a very important work, "The Education of Man," in which he emphasised the pernicious effect of considering development in five separate and distinct stages, as infant, child, boy, youth, and man, and not as life itself shows them, as continuous and unbroken transitions. With Froebel it was of importance that each stage should "depend on the vigorous, complete, and characteristic development of each and all preceding stages of life."

GEORGE FOX PREACHING IN A TAVERN

In February, 1837, he opened the first "Kindergarten," or "Garden of Children," in the village of Blankenberg, near to Keilhau. "As in a garden growing plants are cultivated in accordance with Nature's laws, so here in our child-garden shall the noblest of all growing things, men, that is, children, the germs and shoots of humanity, be cultivated in accordance with the laws of their own being, of God, and of Nature." One of the principal doctrines of Pestalozzi is that every faculty is developed by exercise. Froebel goes further. He would have the child so educated that it will by its spontaneous activity assist in its own development. Parents and teachers should give opportunities for the child to gratify its legitimate impulses. "From action," says Froebel, "must start all true human education."

Perhaps the supreme practical service he rendered to education was his organisation of children's play. Any occupation in which a child finds pleasure it regards as a game; and so Froebel has invented or collected games, physical, artistic, and vocal, "to give children employment in agreement with their whole nature; to engage their awakening mind . . . and especially to guide aright the heart and the affections." The dominant idea of his system of teaching is, to sum up, the superintendence of the child's inherent faculties. His system is the only early educational one that promises to endure, perhaps owing to its simplicity and limitations. Froebel died on June 21, 1852.

MADAME CURIE, THE DISCOVERER OF RADIUM, IN HER LABORATORY

CONTINUED FROM 4469 CONTINUED ON 4701

CHEMISTS & PHYSICISTS

MARIE CURIE

How Radium was Discovered in Poverty

MARIE CURIE was born at Warsaw on November 7, 1867, the daughter of a poor Polish professor named Sklodovsky. From early childhood she was accustomed to make his laboratory at the Warsaw College her playroom, and as she grew older she became his unofficial assistant. Beginning by tidying up the room and dusting the bottles and phials, she came to know the names and properties of all his chemicals, eventually taking to independent research on her own account. Her father seems to have noted nothing uncommon in her aptitude for the work of the laboratory; and it was his students who named her " the little professor," and first directed his attention to her gifts. Still, it was due to her own initiative that she brilliantly passed examinations enabling her to continue her studies in Paris. There she had as her professor, at the physical science laboratory at the Sorbonne, Pierre Curie.

Born in Paris on May 15, 1859, Curie had distinguished himself in a minor way by his careful and refined work on piezo-electricity, on the construction of electrometers, on delicate balances, and on the magnetic properties of iron and oxygen at different temperatures. But there were many men in Paris more advanced than he in the race for fame. Had these two not met, each scientifically the complement of the other, we should in all probability still be waiting for radium. They became man and wife. In due course they learned from M. Henri Becquerel of the radio-active properties of uranium, and undertook a searching quest for these effects in a wide range of materials. The story of that quest is one of the romances of science. The Curies were desperately poor. They worked in a miserable, tumble-down shed for laboratory, with old sacks thrust into gaping cracks and openings, and only a poor little cottage in a squalid neighbourhood as a dwelling.

The couple who were to shake the world with their discovery lived in utter poverty and misery while dragging to light the miraculous secret of the rubbish heap. How the new elements polonium and radium were at last discovered has already been shown on page 1148. The poverty-stricken discoverers at once became famous. A new Chair was created for Curie, while Mme. Curie, who was the actual discoverer, her husband only assisting her in the work, was honoured as no other woman of our generation has been honoured. They had little enough in actual bulk to show for their labours; from a ton of uranium residues they were able to extract but a grain or so of radium salts. And all that they had was temporarily lost not long after the discovery. Curie dropped the phial containing it upon the floor of his laboratory, and scattered every bit of collected radium in the world. Not until every speck of dust had been swept up, and the whole boiled and baked and crystallised, was their anxiety relieved and the imperilled treasure recovered.

While still at the zenith of his fame, M. Curie was accidentally killed in a Paris street on April 16, 1906. Mme. Curie was given a Chair at a university, and continued her labours, with the result that within a year of the death of her husband she succeeded in isolating radium and polonium.

JOHN DALTON

The Schoolmaster who Made Chemistry a Science

John Dalton was born at Eaglesfield, near Cockermouth, Cumberland, on September 6, 1766, into a poor Quaker household, where weaving and husbandry on a small scale barely sufficed for the needs of the little family. Dalton was early distinguished for studiousness and patient application. He left school at the age of ten, but received lessons in mathematics from a sympathetic patron, and in after years was helped by Gough, the blind philosopher, to the acquisition of some French, Latin, and

Greek, and enabled to advance himself in mathematics. While still a boy, Dalton, at a military review, where the onlookers commented on the brilliant uniforms of the troops, asked those about him why the colour of those uniforms differed so little from the colour of the grass upon which they marched. His question was received with derision, but later Dalton worked out the problem for himself, and when twenty-eight years of age read a paper before the Literary and Philosophical Society of Manchester on the visual defect first known as Daltonism. He was the first to discover colour-blindness. It had probably existed in the world since the evolution of the human family, but no one had previously noted it. The searching nature of the tests for colour-blindness to which men in the naval, merchant, and railway services have now to submit is sufficient evidence of the importance of the discovery to civilisation.

MONSIEUR CURIE

At twelve years of age Dalton became a schoolmaster, with a barn for schoolroom and mere babes among his scholars. After two years of this the young dominie quitted the school for the fields of a little farm which his father had inherited, but, with his brother, soon passed over to Kendal to teach in the school of his cousin, whom they eventually succeeded. Dalton was now nineteen, and the two young masters had their sister for housekeeper, while their parents would trudge from Eaglesfield, forty-four miles in a day, to carry them supplies of food. While teaching, Dalton was constantly learning, and, on the suggestion of Gough, began his famous meteorological journal. Thanks to the friendship of Gough he was appointed Professor of Mathematics and Natural Philosophy at New College, Manchester, and when this college was subsequently removed to York he supported himself by private tuition in Manchester. While he was shaking the world with his discoveries in relation to gases, the force of steam, the elasticity of vapours, the expansion of gases by heat, and so forth, he was teaching mathematics at half-a-crown an hour, or performing delicate analyses at the wages of a navvy. When, by the enunciation of his atomic theory, he had elevated chemistry to a science, notable men from many lands went on pilgrimage to his modest home in Manchester, to find the savant placidly earning his bread by teaching some small boy the first elements of arithmetic.

It was in October, 1803, that he laid before the Philosophical Society the first results of his "inquiry into the relative weights of the ultimate particles." In the succeeding year he communicated to Dr. Thomson his theory that matter consisted of indivisible atoms, the atom of each elementary substance having its own weight. Dalton, taking hydrogen as the unity, gave twenty-one atomic weights, each being expressed in atoms of hydrogen. The theory, expounded from the platform and in his "New System of Chemical Philosophy," at once attracted widespread attention, though not immediate general acceptance. Davy was sceptical for a while, but presently declared it the greatest scientific advance of his time, while later he wrote that Dalton "first laid down, clearly and numerically, the doctrine of multiples, and endeavoured to express by simple numbers the weights of the bodies believed to be elementary."

Dalton and his illustrious contemporaries went to their grave believing that the atom he had found was the ultimate and indivisible form of matter; and for a hundred years his theory held good. Since then we have verified the existence of the atom, but have succeeded in splitting it into electrons, in measuring their mass, and recording the velocity at which they move. Dalton discovered a new world for science, and thought it an indivisible whole; it has remained for the scientists of the twentieth

century to penetrate and explore that world, and to prove that it comprises a teeming system of lesser worlds. But Dalton led us to the starting-point.

His investigations were carried out with the most primitive, rough-and-ready implements, mainly of his own fashioning; those of Lord Rayleigh are refined examples of precision by contrast. Dalton was not a skilled experimentalist, and did not make the best of even such tools as he possessed, but his unwearying application, his unfailing memory, and his careful systematising enabled him to triumph over difficulties which to a less extraordinary man would have been insurmountable. He had immense faith in his own work and results, and little for those of his contemporaries, yet he cherished the friendship of many of the great men of his age. Until late in life he submitted to the drudgery of teaching, and rather than sacrifice his independence of action refused a home and £400 a year. He was eventually granted a Government pension of £300 a year, and honours were poured upon him by the learned bodies.

A regular attendant at the meetings of the British Association, he attracted much attention one year by wearing throughout the week the flaming red robe of the D.C.L., which degree was bestowed upon him in 1832. He was the only member of the Association to appear thus garbed. He was equally conspicuous when presented at Court a couple of years later. As a Quaker, he refused to carry a sword, so was allowed to attend in his scarlet robes. The fact is that to Dalton the red robe was of the same colour as grass, and he was quite unconscious of the sensation that his flaring equipment aroused in those free from his limitations.

Towards the close of his life the little family property became his, so that his days closed in what, for a man of such modest requirements, were affluent circumstances. He had "never found time to marry," he said, and lived on the poorest fare, with no expensive tastes and practically no recreations.

Towards the end he displayed certain little eccentricities which are now taken as indicating that his mighty mind was on the wane. Thus, conceiving a liking for Lyon Playfair, whom he heard lecture in Manchester, he said, "I am anxious to present you with a copy of all my works, if you will give me a copy of yours." The young scientist, who loved the venerable seer, modestly replied that he had published but little, and that of small value.

"However," says Playfair, "he insisted that I should put an appraisement on what I had to give, and hand over the difference in money, which amounted, I think, to a little over twenty shillings. I gladly paid this amount, and now possess the works of the greatest of English chemists, with a record in each volume that they had been presented to me as his friend."

Year after year, when the votes for the presidency of the Manchester Philosophical Society came to be examined, it was invariably found that all save one favoured Dalton. The one adverse vote was that of Dalton himself, whose suffrage, year after year, was cast for his friend Peter Clare, the man who devotedly

JOHN DALTON

ministered to his wants during his declining years and infirmities. But on the last occasion that the ballot was taken during Dalton's lifetime it was discovered that he had recorded his vote in favour of electing to the presidency the doorkeeper!

He died at Manchester, on July 27, 1844. His body lay in state at the Town Hall, and in four days over forty thousand persons defiled past the coffin. His funeral was as that of a monarch. Playfair made a post-mortem examination of one of his old friend's eyes, and found that chrome-green and scarlet, the colours which he had been unable to distinguish, appeared in their natural tones when examined with the defective eye intervening.

SIR HUMPHRY DAVY

Who Brought Science to the Man in the Street

Humphry Davy was born at Penzance on December 17, 1778. Although he used proudly at one time to say, "What I am I made myself," he was better born than most self-made men. His father, though a wood-carver by calling, had some means, and came of an old family. Moreover, there was a fairy godfather in John Tonkin, a prosperous surgeon of Penzance, whose fatherly affection for Mrs. Davy and her sisters extended to her children also.

At school Davy was a somewhat wayward genius, inapt to learn set lessons, but the hero of his fellows, whom he entertained with stories and poems without end. Then there was the Quaker counsellor, one Robert Dunkin, who followed saddlery with his fingers, but science with his whole heart, and initiated the bright and amiable little Humphry into the mysteries of the voltaic pile, the Leyden jar, and various electrical machines, and showed him experiments which Davy, when the foremost scientific lecturer of his day, was proud to repeat in the presence of his most distinguished audiences. Loquacious, lovable Robert Dunkin undoubtedly was the father-in-science of the man who was to revolutionise the philosophic thought of his age.

Davy was only sixteen when his father died, and Tonkin apprenticed him to an apothecary, intending that he should eventually become a surgeon. It was in the garret of John Borlase's little shop that Davy began the experiments which were to immortalise him. With the pots and pans of the kitchen, the phials and drugs of the shop, he fashioned his first apparatus; and an old air-pump, given him by the surgeon of a wrecked French vessel, served to unbar the portals of pneumatic chemistry. He falsified current prophecies by not blowing up his employer's family, made small progress in the business side of pharmacy, but substantially extended his knowledge of science. His power of observation and following up a clue is exemplified by two interesting instances.

In the first a child asked him why it was that two pieces of "bonnet cane," when rubbed together, produced a faint light. The youth made an experiment, and was led to the discovery of the siliceous earth in the epidermis of canes, reeds, and grasses. And years later, in one of his brilliant lectures on agricultural chemistry, he repeated his experiment in London, and told how he was brought by a little child to the knowledge. In the second he was debating some point as to the qualities of heat, and Dunkin was against him.

"Humphry," said the worthy Quaker, "thou art the most quibbling hand at a dispute I ever met with in my life!" For answer Davy led him to the river, and showed him how two pieces of ice, on being rubbed together, developed sufficient heat to cause them to melt, and that, the friction ceasing, the pieces became united by what is termed regelation—*i.e.*, a re-congealing even in a warm atmosphere. The same experiment was repeated years later, in a more elaborate form, at the Royal Institution, where it caused a sensation in a fashionable audience.

Davy had the good fortune to make friends of persons of influence at Penzance, visitors and residents; and when Dr. Thomas Beddoes established at Clifton his pneumatic institute for the cure of diseases by the inhalation of gases, Davy, aged twenty, went, much against Tonkin's will, as his assistant. Here he had an opportunity of studying in the well-equipped library of Beddoes, and of meeting many distinguished people. Experimenting with the then little known nitrous oxide, or "laughing gas," he wrote, in 1800, of the power of the gas to ease pain, and predicted its use in the performance of surgical operations. Forty-four years elapsed before Horace Wells, of Hartford, Connecticut, took the hint, and first drew a tooth with nitrous oxide as an anæsthetic. Davy had already published his first series of observations on "Researches, Chemical and Philosophical," and this highly suggestive and original work, coupled with private recommendations, led to his appointment as assistant lecturer and director of the chemical laboratory at the Royal Institution.

He gained immediate success. His lectures and novel experiments attracted audiences such as no scientific lecturer had ever previously addressed, and he was quickly promoted to the foremost position at the Institution. Having at his disposal one of the best electric batteries then existing, he began the famous investigations which resulted in the epochal discovery that the alkalies and earths are compound substances formed by oxygen united with metallic bases. Proceeding from the investigations of Galvani, Volta, and others, he sought to prove that if the poles of a sufficiently powerful battery were brought to bear upon any chemical compound, the components might be separated. The superb

result was his discovery of the elementary metals, potassium, sodium, magnesium, calcium, strontium, and barium.

Another discovery of equal moment was that by which he proved that chlorine is an element, and muriatic (hydrochloric) acid a compound of chlorine and hydrogen. Davy's announcements caused the overthrow of a vast weight of scientific opinion; and the attitude of many of his contemporaries was expressed by a noted Scottish professor, who, addressing his students on the subject, alluded to the now famous discoverer as "one Davy, of London—a verra troublesome person in chemistry."

SIR HUMPHRY DAVY

Davy was now at the zenith of his fame. Irish agriculturists raised a public subscription to induce him to lecture on agriculture in Dublin; and his discourses on the science of agriculture marked a new departure in scientific farming. He was knighted in 1812; married a gifted widow of fortune; resigned his Chair at the Royal Institution to become honorary professor of chemistry; "discovered" Faraday, and travelled with him on scientific pilgrimages in Europe, honoured by passports from Napoleon when England and France were at war; invented his safety lamp for mines; and became a baronet and President of the Royal Society. He continued his researches on chemistry and electro-magnetism until he could no longer work, and died at Geneva on May 29, 1829.

Coleridge, who was among his illustrious admirers, over-praised Davy's poetry, but correctly estimated the value of his work to the world when he said, "He has shown that one common law is applicable to the mind and to the body, and has enabled us to give a full and perfect amen to the great axiom of Bacon, that knowledge is power."

SIR JOHN DEWAR

Who Liquefied Hydrogen and Made Air Solid

Sir James Dewar was born at Kincardine-on-Forth on September 20, 1842. Educated at Dollar Academy and Edinburgh University, he was at twenty-one appointed assistant to Lord Playfair, then Professor of Chemistry at Edinburgh, from whom he received the principal part of his chemical training. In 1868 he spent a few months at Ghent, under the celebrated chemist Kekulé. Here he continued some researches on coal-tar that he had begun at Edinburgh, and from them was developed the Dewar-Körner theory of the pyridine ring, that has helped chemists to produce artificially some of the most complex of organic substances. Sir James Dewar has done good work in many branches of chemistry and physics. One of his important practical discoveries was that of cordite, made in conjunction with Sir Frederick Abel, who also aided him in developing other high explosives used by our Government for military purposes.

The field of work in which Dewar has won most fame is that of researches into very low temperatures. On the occasion of the celebration of the centenary of Faraday's birth, in 1891, he showed in a brilliant lecture at the Royal Institution that oxygen, which is but faintly magnetic at ordinary temperatures, becomes highly susceptible to magnetism when subjected to a great degree of coldness. Throughout his researches he displayed a great personal courage, as well as an inventive skill and a fertility of resource that were highly remarkable. He was the first man of science to succeed in preparing large quantities of liquid oxygen, and by means of the famous Dewar flask he was able to store the liquid for long intervals, and so use it as a cooling agent. His inventive genius was finely displayed in using charcoal to make a vacuum in the double wall of vessels of light metals, such as copper, nickel, and brass. As the vacuum flask

was a non-conductor of heat, its employment led up to his crowning achievement of obtaining hydrogen in the liquid state; but, owing to the want of interest in science that is characteristic of British manufacturers, it was left to a German firm to exploit in a commercial way the wonderful Dewar flask.

Sir James Dewar was only interested in the scientific use of his flask. It enabled him to tackle the problem of liquefying hydrogen, which is, next to helium, the most elusive of all gases. The expenses of the experiment were very heavy, and were generously borne by the late Dr. Ludwig Mond. In a series of difficult and dangerous experiments the temperature was brought down to minus 258 degrees, and the gas then became transformed into a solid resembling frozen foam. This was again cooled by further exhaustion to minus 260 degrees, which was the lowest steady temperature that had ever been reached on this earth. At this extreme coldness ordinary air becomes a rigid, inert solid. Every gaseous substance but one, helium, that is at present known to chemists is solidified. As Sir James Dewar remarked, "As we approach the zero point of absolute temperature, we seem to be nearing what I can only call the death of matter." The existence of this strange condition of things is indicated by the regular diminishing volume of gases, and the gradual falling off in the resistance offered by metals to the passage through them of electricity.

After his success with hydrogen, Sir James in 1906 tackled the last problem in the liquefication of gases, and took up the study of helium. This gas is given off by the King's Well at Bath, and here the famous chemist arranged to accumulate it. But when two years' supply had been gathered in a glass vacuum vessel the vessel collapsed, and Sir James had to begin all his experiments over again. But though his researches were incomplete he was able to predict the probable properties of liquid helium. His prediction has been closely verified by Professor Onnes, the Director of the Physical Laboratory at Leyden, who has succeeded in producing liquid helium.

In 1875 Sir James Dewar was appointed Jacksonian Professor of Natural Experimental Philosophy at Cambridge, and two years afterwards he was made Fullerian Professor of Chemistry to the Royal Institution; he is also Director of the Davy-Faraday Research Laboratory. In conjunction with Professor Moissan, he has produced fluid fluorine, and he was the first man to study the important subject of the oxidation products of quinoline. He is a man of middle height and impressive appearance, with a strong, clear-cut face and deep-set eyes. In private life he is well known as a collector of works of art, and his library is famous for its rare and interesting books. He was knighted in 1904.

MICHAEL FARADAY

The Founder of Electrical Science

Michael Faraday was born at Newington Butts, London, on September 22, 1791. His father, a Yorkshireman, was a blacksmith of limited means, and Michael began his career, at twelve years of age, as an errand boy in the service of one Ribeau, a bookseller, who bought up odd lots from printers and bound or rebound them for sale. At the end of the year Faraday had so well pleased his kindly employer that Ribeau took him as apprentice, without premium. Here he remained until he was twenty-one, reading, experimenting in electricity with home-made apparatus, attending popular lectures by the lesser men of his time, cultivating valuable private friendships, and laying the foundations not only of his wonderful intellectual equipment but of that beautiful character which endeared him to so wide a circle.

His career may be said to have turned upon a pretty accident. When Faraday was in his twenty-first year, one of his master's customers, who happened to be a member of the Royal Institution, called at the shop, and found the young man poring over an article on electricity contained in an encyclopædia which he was binding. The visitor, ascertaining from Ribeau something of the industrious apprentice's character and habits, gave the lad tickets for the last four of a series of lectures which Davy was delivering at the Royal Institution. Faraday was present at the lectures, and has given us the story of the sequel. "I took notes, and afterwards wrote them out more fairly in a quarto volume. My desire to escape from trade, which I thought vicious and selfish, and to enter the service of science, which I imagined made its pursuers amiable and liberal, induced me at last to take the bold step of writing to Sir Humphry Davy, expressing my wishes and a hope that, if an opportunity came in his way, he would favour my views. At the same time I sent the notes I had taken of his lectures." The effect was sensational.

Davy, who was just starting for a holiday, carefully considered his disciple's notes, realised that their writer had an exceptional grip of his subject, and promised to see him later. And it all happened in the manner of the fairy story. Faraday was getting into his humble bed one night when there was a thundering knock at the door, and, lo! the splendid carriage of Davy was discovered in the street. A servant in livery handed the apprentice a note, bidding him wait upon the great man next morning.

At the interview, Davy, after mentioning all the obstacles in the way of a scientific career, gladly took up the young man's cause, and in due season engaged him as assistant at twenty-five shillings a week. The transaction was one which did credit to Davy's discernment as well as to his generous nature, and, with all sincerity, he said in after life, when congratulated on his immense achievements, "My best discovery was—Michael Faraday."

Faraday soon came to assist his master in his lectures; shared the perils of the laboratory when Davy was conducting his epoch-marking discoveries; lectured in that lesser world in which he had himself gained his alphabet of science; then, when Davy went abroad, accompanied him, as amanuensis, valet, secretary. Lady Davy behaved very badly to Faraday, emphasising the menial aspect of his position, so that at one place where they stayed Faraday was given his meals with the grooms. Upon returning to London, Faraday plunged into new and unsounded deeps of science. Having already made a number of important discoveries in chemistry in conjunction with and for Davy, he succeeded the latter upon his retirement, in 1827, at the Royal Institution, with which, all told, he was connected for fifty-four years.

He refused the Presidency of the Royal Society and that of the Royal Institution, and avoided all titular distinctions save that of D.C.L.; he refused what might have been a fortune in commercial pursuits, and at first declined a pension offered in contemptuous terms by Melbourne, whose attitude was typical of the low esteem in which science and learning were held by the ignorant and intolerant governing classes of the age. When, however, Melbourne realised that he had a really great and noble man, as well as a mere scientist, to deal with, he apologised in the handsomest way, and made it possible for Faraday to accept a Civil List pension of £300 a year, to which in due course was added the tenancy of a house at Hampton Court.

Faraday married at thirty a charming, helpful woman, and it was his wife to whom he first showed his successful experiment in

MICHAEL FARADAY AT WORK IN HIS LABORATORY

causing the magnetic needle to revolve round an electric current. Faraday's labours range over a great part of the domain of chemistry, electricity and magnetism. He kept a record of his experimental researches, each numbered. The last is numbered 16,041. From his work resulted the electric telegraph and telephone, and a myriad applications of electricity and electro-magnetism which today are among the greatest driving forces of civilised communities. His experiments with chlorine crowned the work of Davy, and presented a gift of incalculable riches to our textile industries. He was among the pioneers in the creation of steel alloys, and from one of his first successes caused a razor to be made which Tyndall used to the end of his days. His study of optics paved the way to great improvements in the manufacture of glass and in the illuminating of lighthouses. Photography is traceable to his investigation of the vaporisation of mercury at an even temperature; his liquefaction of gases has been fruitful of many subsequent discoveries. Acoustics, the conservation of forces, the application of induced electricity to the firing of mines, lighthouses, telegraphy, etc.; the electro-tonic composition of matter, the identity of various forms of electricity, whether from an eel or a battery; the equivalents in electro-chemical decomposition, electro-static induction, hydro-electricity, magnetic rotary polarisation, and so on through an almost inexhaustible list—these are among the discoveries that make his name immortal, and his labours the foundation of electrical science.

Faraday was not only a great and successful discoverer in the untrodden ways of science; he carried a vast host of discerning disciples with him. He inspired with zeal and ardour a generation which worthily carried on the work that he had begun. He had the supreme gift of making the dry bones of science live. His lectures to the uninitiated were models of lucidity and charm. Without offending the intelligence of an audience, he remembered that they were not laboratory experts, and in language which all could understand, and high scientists not despise, he would tell the startling story of some new and revolutionary discovery with complete simplicity and directness. This characteristic greatly enhanced the value of his own work. He made the teachings of other men plain and attractive; he explained his own discoveries in terms which riveted the attention of all who heard him. His lectures, though designed to appeal to the intelligence of the unscientific, were always characterised by a simple dignity and beauty of language, often reaching real eloquence, so that a hundred records, from orators, scientists, artists, men of the world, attest the success of those wonderful séances at the Royal Institution.

Some of his lectures, such as that on the chemistry of a candle, still sell, and remain models of what the scientific lecture should be, and his volume on chemical manipulation is still a classic. "I thank God that I was not made a dexterous manipulator, for the most important of my discoveries have been suggested to me by failures," said Davy. Faraday might have returned thanks that he *was* born a dexterous manipulator, for had it not been for the exquisite delicacy of his experiments the world might have had to wait indefinitely for inventions which are now an indispensable aid to the affairs of everyday life.

In private life Faraday was gentle, affectionate, charitable, trustful yet discerning, an unswerving friend, a very present help in trouble to those still struggling up the ladder of learning. He once summed up his career in these words: "I am no discoverer, but simply one of a vast crowd of workers scattered over the earth, who in the providence of God are invested with some portion of the Divine afflatus, and appointed to show forth His mercy and loving-kindness in conferring fresh benefits on His people; the varied merits of such agents being evinced in the comparative zeal and self-sacrifice with which they carried out the mission entrusted to them." His biographer adds—"Faraday was one of that long line of scientific men, beginning with the savants of the East, who brought to the Redeemer the gold, frankincense, and myrrh of their adoration." Faraday died at Hampton Court on August 25, 1867.

EMIL FISCHER

A Great Constructive Chemist

Emil Fischer, one of the greatest of living chemists, was born in Euskirchen, in Rhenish Prussia, on October 9, 1852. He was educated at Bonn, and studied chemistry at Strassburg; then he acted as assistant to Baeyer at Munich for eight years. At twenty-three he made his first discovery of a new compound of hydrogen and nitrogen, known as hydraxine, which proved to be of great practical importance. Later, he showed that Sir William H.

Perkin's coal-tar dye, magenta, was derived from the base he discovered, and he also found the parent substance of indigo. In all this work he only trod in the well-beaten path of research of his master, Baeyer. But in 1881 he became more original, and from this date his contributions to chemistry are unique in extent, character, and completeness. The main significance of his work is its relation to the processes of living bodies—a subject of ever-increasing interest.

In an arid and sterile period in physiological chemistry, he turned the force of his genius to the making of substances intimately connected with the processes of life. By 1883 he had taken up the waste

EMIL FISCHER

product of living bodies, urea, and had shown how it was built up and related to the stimulating principle in tea and coffee and cocoa. Then, by a remarkable skill in creation, he manufactured from uric acid the caffeine of tea and cocoa, and the theobromine in cocoa-beans and kola-nuts. He next attacked the sugars, and showed of what they were made, and in many cases made them in his laboratory.

On the death of Hofmann he was appointed Professor of Chemistry and Director of the Laboratory at the University of Berlin. Here, since 1892, he has worked at the head of a brilliant troop of assistants, drawn by his fame from all parts of the world, and including many young English and Scottish men of science. The most difficult and the most interesting of all branches of chemistry has engaged his attention. This is the chemistry of the albumins, or proteins, which are colourless substances composing the solid constituents of animal tissues, and the secretions of animal and plant cells and other products of life. They play a most essential part in the world of living matter, and they are the most complex of substances.

In 1889 Fischer succeded in breaking some of these albumin substances into simple amino acids, which are compounds of ammonia. The remarkable thing about Fischer's work is that he usually proves that his analysis of a substance is correct by taking the elements he has found in it and building up an artificial product similar to or identical with the natural product. This he has done in the case of the albumins or proteins. In 1910 he was able to show the German Emperor a small amount of synthetic protein which could be used as food. It was the most complicated substance ever evolved by synthesis. The materials for it cost £50, and if the labour expended on it had also been counted its price would have been still more extraordinary. It has not yet made its appearance at the dinner-table! But though today it is nothing but a chemical curiosity, tomorrow it may be of the greatest value. For though it is simple in structure when compared with the white of an ordinary egg, it solves the mystery of the most complex forms of living matter. Emil Fischer himself considers that the synthesis of all the proteins is only a question of trouble and cost.

Owing to Fischer, chemistry has now become an important factor in the solutions of the great riddles of life—nourishment, growth, reproduction, heredity, age, and disease. He has made out of ammonia the uric substances found in the muscles of the body and in the nuclei of living cells. He has laid bare the structure of sugars and starches, which are among the most important foods of man, and he has succeeded in creating these things by artificial means; and now he has attacked the proteins of animal tissue. In 1912 he took up the study of the tannins, which were one of the mysteries of modern science. For sixty years chemists have been trying to find out their structure, but without success. Fischer has discovered that by combining glucose with a certain kind of gallic chloride he can obtain a compound with all the properties of the tannins. So synthetic tannin, of

considerable commercial importance, may soon be added to the achievements of the Berlin School of Chemistry.

At the present time Emil Fischer is trying to solve the ultimate secret of the processes of living bodies. By a peculiar chemical power, living matter can quickly and easily break up gases of the air and foodstuffs into simpler substances. Things that take a chemist a long time to perform are effected instantaneously in the living body. This is done by means of small amounts of curious chemicals produced by the tissues and known as enzymes. At present they cannot be imitated in a chemist's laboratory, but Fischer has already found that they are

LUIGI GALVANI

related to more simple substances. If ever enzymes and similar powerfully small agents can be manufactured cheaply in chemical works, a new and mighty kind of force will be placed at the service of mankind.

LUIGI GALVANI

The Discoverer of Animal Magnetism

Luigi Galvani was the luckiest of all famous men of science. By the purest accident he discovered the principle of the galvanic battery, and, though he could not understand his own discovery, another Italian man of science was able to bring out its high importance. Galvani was born at Bologna on September 9, 1737. In his early youth he devoted himself with passion to the study of theology, with the intention of becoming a monk. With the greatest difficulty his father prevented him from entering the monastery. It was only by pointing out to him that the work of a doctor was a more noble way of sacrificing one's self to the cause of suffering humanity that the lad was turned from the path of life he first wished to follow. He threw himself into the study of medicine with the same intense energy with which he had taken up theology, and in early manhood he became one of the most brilliant surgeons of his time. By a treatise on the formation of bones he won, in 1762, the professorship of anatomy in the university of his native town.

Twenty-four years passed before the merest hazard led him to the discovery of galvanism. His wife was attacked by a disease of the chest, and to maintain her strength she was fed on a broth of frogs' legs. Galvani, who loved his wife with deep and burning affection, always put all his work aside in order to prepare a broth with his own hands. One morning he had placed on his laboratory table, close to an electrical machine, some dead skinned frogs, and a fine knife that he used in his anatomical researches rested on one of the little creatures. He left the room without noticing anything, but his wife entered, and was surprised to see the limbs of one of the frogs moving in a strange, convulsive manner. Instead of being frightened, she tried to find out the cause of this apparent miraculous return to life of a dead frog. With great sagacity she traced it to the current produced by the electrical machine. She ran and told her husband, and he at once verified her brilliant idea. He laid the point of the knife on the nerves of one frog after another, while the electrical machine was not working, and the curious contraction of the muscles of the dead creatures did not occur. But as soon as a current of electricity was generated in the machine the current seemed to pass through the surgical knife and affect the nerves of the dead frogs.

Galvani wondered if a discharge of lightning would produce the same effect on the legs of a dead frog. Waiting till there was a feeling of thunder in the air, he ran a copper skewer through the frog's legs and suspended them to an iron railing on the balcony of his house. As soon as the copper touched the iron, the strange convulsive twitchings of the tiny dead limbs again recurred. Much to his surprise, Galvani

discovered that the extraordinary effect could be produced in any weather and at any time of the day. As soon as the copper skewer was fixed in the iron railings the frog's legs seemed to come alive.

He arrived at the conclusion that all animals were endowed with a particular electricity which was secreted by the brain and distributed by the nervous system to the body, where the muscles acted as reservoirs of the strange force. He was quite wrong in his theory of the matter. The electricity did not reside in the animal tissue, but was produced by the contact of the copper skewer and the iron railing. The famous anatomist merely created a primitive kind of electric battery out of copper and iron and moist animal tissue. But though his ideas were incorrect, his experiments opened up a large, new, and important field in electrical science. The only way known to his contemporaries of producing an electric current was by friction, and it was a friction machine that the professor used in his laboratory.

But his experiment with a frog's leg, a copper skewer, and an iron railing showed that electricity could be generated with ease and abundance through the chemical reaction of various forms of matter. Thus a new source of energy was discovered; and we are not yet able to tell fully what effect it may have on the destinies of the human race.

It is far more economical to use an electric battery in exploiting the energy of various substances than to attempt to extract power from them by the application of heat. If some way were found of using our coal in a battery instead of in a fire or furnace, a mighty advance would be made in all kinds of industries. And though this has not yet been done in an entirely practical way, yet the lucky experiment of Galvani may some day be developed into an achievement of tremendous importance.

Galvani lost his professorship at Bologna when Napoleon invaded Italy. He was asked to swear allegiance to the new Cisalpine Republic, and he would not do so. So great was his fame that a special edict was published by the Government restoring him to his position without asking him to take an oath, but the edict appeared too late. The death of his beloved wife, and the poverty and trouble into which he fell, sapped his vitality, and he died in his native town, amid general regret, on December 4, 1798, a broken-hearted man.

JOSEPH LOUIS GAY-LUSSAC

Discoverer of the "Law of Volumes"

Joseph Louis Gay-Lussac, one of the master-builders of modern science, was born on December 6, 1778, in the little town of Saint-Léonard-le-Noblat, in Limousin, France. His father was a judge, and but for the Great Revolution the son would no doubt have been in turn a well-to-do legal dignitary. But when the French people rose against their king the provincial judge was thrown into the prison into which he had sent many men, and in the days of the "Terror" an order was made for him to be brought to Paris to be tried and guillotined. The fact that he had been an officer of the Crown was sufficient to condemn him. But Joseph, then but a brilliant boy of fifteen, so worked upon the good feelings of the governor of the gaol that the judge, who had in the days of his power made himself respected by his kindness, was allowed to remain in the prison of the little town, forgotten by the Terrorists of Paris.

JOSEPH GAY-LUSSAC

He was set free at last; and though he had lost his position and his wealth he managed to send his son to school at Paris in 1795, and after the school was broken up young Gay-Lussac entered the famous Polytechnic School. To diminish the sacrifice his father had to make to get money for his education, the lad worked at night on his own studies,

and spent all his leisure hours in the daytime in giving lessons to younger boys. In this way he managed to save his impoverished family some expense, so that sufficient money remained for his brother to study for a medical career. Naturally, Joseph had to work very hard, and there was some danger of his health giving way through want of rest and sleep. On the other hand, the difficulties of his position gave him an impetus to study that few other boys possessed, and in three years he had become an excellent engineer, with a passion for chemistry. He left the school with the career of a bridge-builder open to him, but he had happily attracted the notice of the famous chemist Berthollet, who offered him a position in his laboratory. Naturally, Gay-Lussac jumped at it, for Berthollet was a friend of Napoleon, and the leading chemist of the age, and he had a splendid collection of chemical instruments.

Gay-Lussac at once showed a remarkable talent for chemistry, and Berthollet, glad to find that the lonely, hard-working young man had more knowledge and skill than even he had fancied, obtained for him the position of assistant professor in the Polytechnic School. In a few months the young man had distinguished himself by his discoveries and by his gift for teaching others. He took up the study of the law of gases, and showed that the volume of a gas increases at an ascertained and definite rate with the rise in temperature.

His work on gases attracted the notice of other French men of science, and on April 2, 1804, they entrusted him with a very exciting and adventurous piece of research. Some Russian balloonists had taken observations high in the air that seemed to show that the influence of the earth's magnetism rapidly diminished at a great height above the ground. Gay-Lussac and another young man were sent up in a balloon, provided with the necessary instruments for studying this curious problem. They ascended to a height of 13,000 feet, and found that the magnetic needle there behaved exactly as it did on the surface of the earth. But Gay-Lussac was now carried away by the love of scientific adventure; he wanted to explore the air at heights unreached by man.

He set out alone on September 16, 1804, on another balloon voyage. He rose over 23,000 feet, and though his breathing at this height was somewhat troubled he was far from feeling any disagreeable sickness. But he found the air so dry that it acted on his throat, and made the eating of the bread he had brought up with him a rather painful operation. No one before him had reached so great a height, and no later explorer of the air has been able to mount as high without great bodily trouble. The ease with which he made his record is still a matter of wonder. He collected some air at his extraordinary elevation, and on analysing it after his descent he found it was composed in the same manner as that collected at the surface of the earth. His great discovery was in regard to the amount of heat in the air. For he found that the temperature diminished rapidly and with apparent regularity the higher he ascended. It is only lately that his law of the diminution of temperature above the earth has been checked and extended by means of unmanned balloons fitted with self-registering thermometers. Altogether his daring and magnificent balloon ascent was a remarkable and valuable piece of work.

Returning to the study of gases, Gay-Lussac became one of the most famous of the master-builders of chemical science by an apparently simple study of the way in which oxygen and nitrogen combined together. It was related to the problem of weighing the atoms of compound substances; and when Dalton's theory was altered and simplified by the famous Italian chemist Professor Avogadro, the discovery of Gay-Lussac's law of volumes became of extreme importance. It is only within the last thirty years or so that the true meaning of the facts established by Gay-Lussac and the interpretation given by Avogadro have been generally recognised; and much of the modern advance in chemistry has been due to that recognition.

In 1809 Gay-Lussac was made Professor of Chemistry at the Polytechnic School. Seeing a girl in a milliner's shop with a book of chemistry in her hand, he resolved to marry her, and he did so. In the course of a long and happy life he further distinguished himself by discovering iodine and cyanogen and prussic acid. He was made a peer of France in 1839, and he was generally recognised as one of the greatest of scientific authorities for many years before his death, on May 9, 1850.

WILLIAM GILBERT

The Greatest Scientist of Elizabethan Times

William Gilbert, the father of the sciences of magnetism and electricity, was the son of a Recorder of Colchester, at which town he was born on May 24, 1544. Little is known of his boyhood, but at eighteen he

matriculated at St. John's, Cambridge, where he remained for seven years. At twenty-one he was elected a Fellow of his college and examiner in mathematics. But a quiet life of study and teaching did not attract him. He had the Elizabethan passion for freedom and excitement of life, and, taking up the study of medicine as a means of existence, he won his doctor's degree in 1569, and then spent three years in foreign travel. Italy appealed most to him, for there he found groups of far-ranging, earnest inquirers into those mysteries of Nature on which it was the passion of his life to cast some new light.

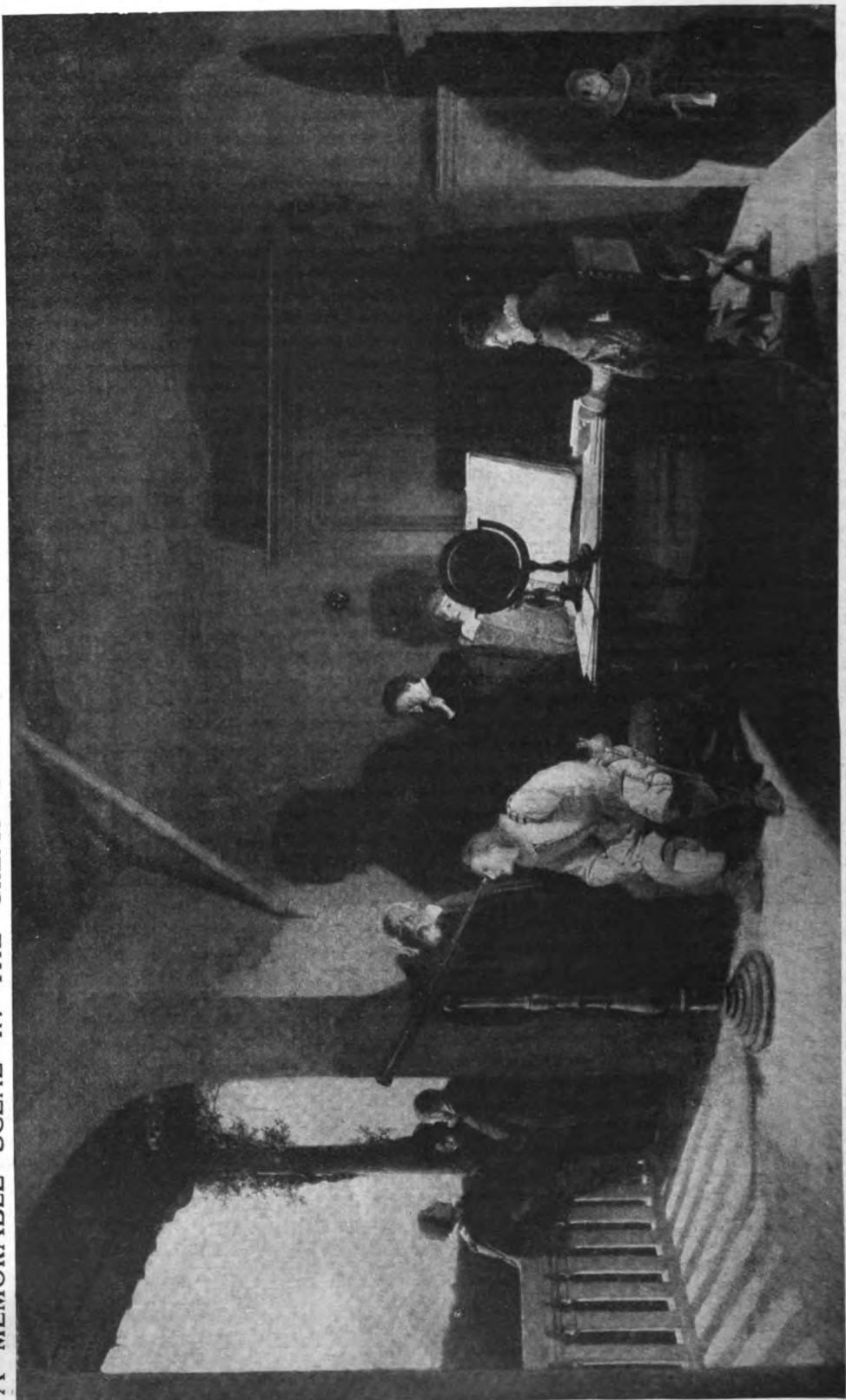
Returning to London in 1573, he showed himself an able physician, and soon worked up a good practice. He became President of the College of Physicians, and both Queen Elizabeth and King James appointed him their doctor. But, in spite of his success in the study and practice of medicine, Gilbert only regarded his calling as a means to an end. It supplied him with the money he needed for other work, and the social position he won brought him into contact with Sir Francis Drake, the representative of the class of men who most interested him. Drake especially was able to help him by studying the curious behaviour of the compass when his ship was sailing through distant seas; the observations that the great English sailor made in the matter were of considerable assistance to the first great English man of science of the modern school.

At the time when Gilbert took up the study of the mariner's compass, the subject was more involved in mystery than it had ever been. Columbus had noticed, when two hundred leagues from Europe, the variation of the needle from the true north. And so had Cabot. Later on an Englishman, Robert Norman, discovered that the needle had a tendency to dip according to the latitude in which the ship was that carried it. But nobody divined the reason for this strange behaviour of the compass. Some persons thought that the Pole star was an immense magnet that attracted the magnetic needle; others supposed there was an island or mountain of magnetic ore in the Arctic regions, towards which the needle pointed. It was said that when a ship approached this island all the bolts and nails that held the timbers together flew out, and the vessel fell in pieces. Some ancient doctors used powdered magnets as a purge for melancholy, and even in Gilbert's lifetime poultices were made out of ground lodestones by Paracelsus.

It was Gilbert who rescued the study of the magnet from the atmosphere of wild superstition and placed it on a scientific basis. From the observations that his sailor friends made under his directions, he arrived at the grand fact that the behaviour of the compass was to be explained on the theory that the earth itself was a great magnet. Then came the discovery by which he proved his theory. He placed a rod of iron pointing north and south, and hammered it so that it became magnetised by the influence of the earth's magnetism. After spending £500 on experiments of this kind, he sufficiently verified his theory to publish it in 1600 in his famous work "De Magnete."

Besides solving the mystery of the magnet, this book contains a short digression on the properties of amber. The Greek word for amber is "elektron," and from it Gilbert derived his term for the strange property that amber possessed when it was rubbed—electricitas. It had been known for more than two thousand years that if a piece of amber were rubbed on a woollen cloth it would attract small pieces of straw or woody fibre. At a much later time it was found that jet, when rubbed, possessed the same power of attraction. That was all that was known about electricity when Gilbert was led to study it in connection with his experiments on magnetism. He made a light needle of metal, pivoted like a compass on a pin, and with this rough electroscope he tested the electrical properties of other substances, and found that many things besides amber and jet could be so electrified by friction as to make his needle move when brought close to it. He was the father of electricity, but he left his child in its infancy.

For he died on November 30, 1603, a few years after making his first experiments. He also founded a society for the promotion of science, but this unfortunately broke up on his death. As a man of science, working strictly on the inductive method, Gilbert was much superior to his famous contemporary and countryman, Bacon. Yet Bacon sneered at him as a man who had "made a whole philosophy out of observations on a loadstone." He even accused Gilbert of creating fables. But there was one man in Europe who recognised at once the achievement and genius of the English doctor. "I extremely admire and envy the author of 'De Magnete,'" wrote Galileo.

A MEMORABLE SCENE IN THE GREAT DAYS WHEN CREATION WIDENED TO MAN'S VIEW

GALILEO SHOWING TO JOHN MILTON THE MARKINGS ON THE MOON, AS SEEN THROUGH HIS NEW TELESCOPE

ASTRONOMERS

FRANK WATSON DYSON

Astronomer Royal at Greenwich

Frank Watson Dyson, the present Astronomer Royal, was born at Ashby on January 8, 1868. His father was a Baptist minister of that town. Dyson was educated at Bradford Grammar School, and Trinity College, Cambridge. He graduated as Second Wrangler and Smith's Prizeman, and was made a Fellow of his college. In 1894 he was appointed chief assistant at the Royal Observatory, Greenwich, where he remained until his appointment, in 1905, as Astronomer Royal for Scotland.

In 1901 a total eclipse of the sun in Sumatra drew many astronomical expeditions thither, the observers being posted at fifteen stations along the line of totality. Mr. Dyson was among these, his position being at Auer Gadang, and he was one of the few who succeeded in securing photographs of the corona, the meteorological conditions being extremely unfavourable. On his photographic plates the spectrum of the corona gave an impression continued farther into the ultra-violet than had ever before been obtained. Among other investigations carried out by Mr. Dyson may be mentioned those upon the systematic motions of stars.

After five years as Astronomer Royal for Scotland, Dyson was appointed to succeed Sir W. H. M. Christie, at Greenwich. as Astronomer Royal, in 1910. In the same year he brought out a valuable text-book, "Astronomy: A Handy Manual for Students and Others." He has also written a large number of papers on mathematical and astronomical subjects.

JOHANN FRANZ ENCKE

A Calculator of Planetary Orbits

Johann Franz Encke was born at Hamburg on September 23, 1791. His father, a clergyman, died when the boy was about five years old. His own leanings were always towards mathematical studies, but, his mother becoming very ill in 1811, he decided to study medicine, as it offered a much better chance of remuneration. However, his mother died the same year, and, reverting to his favourite mathematical studies, he proceeded to the University of Göttingen. Here, under Gauss, he became an enthusiastic astronomical computer. In 1813 his studies were interrupted by the call for men to serve with the Hanseatic Legion in the war. Encke at once enrolled himself, and served at the front, becoming a lieutenant. He had returned in peace to Gauss and astronomy when Napoleon's escape, in 1815, called all back to the standard, and he proceeded to Berlin. Here he met Bode, who remained his friend all his life.

In 1816 Encke was appointed to the Seeberg Observatory as assistant to Lindenau, and from 1817 to 1818 was in charge of all the work of the observatory during Lindenau's absence. In 1820 he was appointed vice-director, and in 1822 director, at Seeberg; in 1825 he was made director of the Royal Observatory at Berlin as successor to Bode.

Encke's great work was the computation of cometary orbits, and other computations no less valuable to astronomical science. These were his delight, and in order to be free to devote himself to observation and calculation he refused three offered professorships—at Greifswald, Jena, and Marli. The most famous of his computations was the orbit of the comet discovered by Pons in 1818, for which he determined an elliptical path occupying 3⅓ years, and identified former appearances in 1805, 1795, and 1786. These calculations made him famous, and the comet became known as Encke's Comet. On each return after this, Encke predicted the time of perihelion passage, and found each time that the comet's pace had accelerated somewhat,

from which fact he concluded the existence of a resisting medium in space. Many other cometary orbits were computed by him.

Another important piece of work which Encke carried out was the computation of the sun's distance much more exactly than it had been computed before.

Greater accuracy has since been obtained, but his results were of great value. They were derived from careful observation of the two transits of Venus in 1761 and 1769, and were published in a treatise, "The Distance of the Sun." He computed also the mass of Mercury and the movements of some of the asteroids.

In 1864 Encke retired from the Berlin Observatory, his health being much impaired. He lived a retired life at Spandau until August 26, 1865, when he died.

EUDOXUS

The Bringer of Astronomy from Egypt to Greece

Eudoxus of Cnidus was born in that town about 400 B.C. He early imbibed the learning of his day in all its branches, including philosophy, medicine, astronomy, and mathematics. Astronomy he learnt from the priests of Heliopolis during a stay of about a year and a half in Egypt. On his return he founded in Cnidus a school and an observatory, and introduced to the Greeks the knowledge of the true length of the solar year, which had been known to the Egyptians for many hundreds of years. This length, 365¼ days, was introduced into the Julian Calendar.

Eudoxus is famous as the inventor of the theory of concentric spheres, by which he sought to reduce to harmony the complicated motions observed in sun, moon, and planets. This he did by ascribing to each body a set of concentric spheres, moving with uniform motions, the observed motion of the body being the resultant of these composites. To the sun he ascribed three, to the moon the same, and to each of the planets four of these spheres. His theory was adopted by Aristotle and many teachers, and more and more spheres were added as further complexities were discovered in the motions of the heavenly bodies. The resultant confusion of this imaginary plethora of spheres was swept away by the establishment of the Copernican system.

Eudoxus is known to have made many observations of Canopus, and to have estimated the diameter of the sun in terms of the moon. This last he placed at the ridiculously low estimate of nine times, but even that was an extraordinary advance on prevailing notions.

Eudoxus is credited with the invention of an instrument for measuring time, which consisted of such a complicated network of lines that it received the name of the "Spider." He is known to have written a good many treatises on astronomical and other subjects; two of these were embodied in poems by Aratus, and their substance has thus been preserved—the "Phenomena" and the "Mirror," the last dealing with the constellations. Other fragments have been preserved in the writings, of Hipparchus. Attempts have been made to use the writings thus transmitted secondhand to compare the sky now with the sky then; and there is no doubt that a remarkable similarity is confirmed, though the indefiniteness of the early writers does not permit the comparison to be made in great detail.

Aristotle has given us some idea of the philosophical views of Eudoxus, which consisted chiefly in a belief in the supreme value of pleasure, without, however, any clear differentiation between pleasures of higher and lower kind. Against this view Aristotle argued, while paying a tribute to the sincerity with which Eudoxus advanced his opinions. Eudoxus is believed to have died about 356 B.C.

JOHANN FABRICIUS

A Student of Sunspots

Johann Fabricius was born at Osterla, near Norden, in East Frisia, his father, David Fabricius, being pastor of that place. David was himself an amateur astronomer of considerable repute, and had spent some time as a young man at Uranienburg with Tycho Brahe. As a pastor, astronomy was still his recreation, and took up much of his time; and his son early imbibed this taste for observation. David Fabricius was too poor to buy astronomical instruments, but constructed several for himself, including a sextant and a quadrant; and Johann as a young man learnt in Holland the art of telescope construction. In 1610 he turned his telescope upon the sun, and observed the phenomena of sunspots. The honour of their first discovery is claimed for him as well as for Galileo; it has also been claimed for Scheiner and Harriot. But, as Mr. Bryant points out, "the real credit lay with the telescope, so that the question of priority is of no importance." Johann Fabricius, however, was the author of the first book dealing with sunspots. This was brought out in 1611. It was considered by Lalande of sufficient importance to be reprinted in a memoir of the French Academy of Sciences in 1778.

David Fabricius, the father, has no rival as the first discoverer of the famous and beautiful variable star Mira Ceti, in 1596.

The date of Johann's death is not known. The only certain fact is that he was still alive in 1617, the year of his father's death. David Fabricius was killed by a peasant whom he had publicly rebuked as a thief.

JAMES FERGUSON

The Shepherd Lad who Taught Astronomy

James Ferguson, the first successful popular writer and lecturer upon astronomy, was born on April 25, 1710, near Rothiemay, in Banffshire. He was the son of a poor labourer and small holder, taught himself to

JAMES FERGUSON

read, and had in all only three months' schooling. But from his earliest years he showed extraordinary ingenuity in mechanical construction and in drawing. He served as a shepherd boy and labourer in one place after another, but was always working in leisure hours at mechanical contrivances, and at night studied the stars with ever-increasing interest. This scientific bent, together with his exceptional dexterity in drawing portraits with pen and ink, attracted the attention of his employers and their wealthy and fashionable friends; and in 1734 Ferguson began to practise as a portrait-painter in Edinburgh. He followed that profession for twenty-six years. In 1737 he moved to Inverness, married in 1739, and was again in Edinburgh in 1742, constructing an orrery, or machine representing the relative movements of the planets round the sun. The portraits were mere potboilers, and Ferguson's chief interest was astronomy.

Next year he went up to London, and soon established a large portrait connection. Having caught the attention of the Royal Society by a large diagram of the course of the moon, which he had discovered to be always concave to the sun, he read a paper to the society on the supposed seasons of Venus. His career as a popular lecturer in science began in 1748, and was pursued with unprecedented success for many years, not only in London, but also throughout the provinces. Astronomy was his principal though not his only subject, and he illustrated the motions of celestial bodies, and the movements of the tides, by a great variety of machines which he had himself invented. His power as a scientific teacher was due not only to his ingenious apparatus, but also to a remarkable clearness of mind and language.

Ferguson was the Sir Robert Ball, or the Camille Flammarion, of the eighteenth century. He was author of the first really popular astronomical book, entitled "Astronomy Explained on Sir Isaac Newton's Principles," 1756. He wrote other works also, including "A Plain Method of Determining the Parallax of Venus by her Transit Over the Sun." In 1761 he received a pension from George III., and died in London on November 16, 1776.

CAMILLE FLAMMARION

The Popular Astronomer of France

Camille Flammarion was born at Montigny-le-Roi, in the Department of Haute-Marne, on February 25, 1842. At first intended for the Church, he was educated at the Ecclesiastical Seminary at Langres, but the love of astronomy took hold of him, and he never seriously began his studies for the priesthood. At the age of sixteen he became assistant to Le Verrier, and remained four years at the Paris Observatory. He then qualified for a post in the Bureau des Longitudes by a year's study in mathematics at the Sorbonne. From 1863 to 1867 he held this office, editing at the same time the journal "Cosmos," and from 1865 the scientific section of the "Siècle."

In 1882 Flammarion founded the paper "L'Astronomie," and in 1887 promoted the Société Astronomique de France, of which he was the first president, and afterwards secretary. Since 1867 he has

delivered many lectures on astronomy, which are as interesting and popular as his books. His many writings are characterised by a fervid and highly coloured style. He is carried away by a kind of rapture in the contemplation of immensity, and of the insignificance of human destiny which that immensity conveys to him. His books owe their wide popularity partly to this literary quality, but also to their clear presentation of scientific facts.

Camille Flammarion is an experienced practical astronomer. In 1883 he built his own observatory at Juvisy sur-Orge, where many observations of great value have

JOHN FLAMSTEED

been made. His most important work has been in connection with double stars, and with "star-drift," a phenomenon pointed out by Proctor. He has computed the periods of many binaries, and has shown that many supposed double stars are merely optical pairs. These last formed a long list presented to the French Academy in 1878. Between 1873 and 1877 he investigated the motions of a great number of double stars in relation to the theory of star-drift, or of systems formed by stars at a great distance apart, and the results were published, in 1878, in a "Catalogue of Double and Multiple Stars in Certain Motion." Other investigations have included variable stars, of which he compiled a comprehensive catalogue from the catalogues of all ages; the planets Mars, Jupiter, and Saturn; the moon; and the aurora and other problems of terrestrial magnetism. His books include "Marvels of the Heavens," "The Atmosphere," "Omega, the Last Days of the World," "Popular Astronomy," "The Unknown," and "Astronomy for Amateurs," all of which have been translated into English.

JOHN FLAMSTEED

Finder of Twenty Thousand Stars

John Flamsteed, first British Astronomer Royal and author of a famous catalogue of the stars, was born at Denby, near Derby, on August 19, 1646. He was sent to school at Derby, but his education was cut short at the age of sixteen by severe rheumatism, for which many cures were tried in vain. Thus kept at home, he took to the study of astronomy, poring over old books and making observations with a rude, home-made quadrant. Finding that the moment of an eclipse of the sun, which he observed in 1668, differed greatly from the time predicted, he took up astronomical calculations, and in the following year a paper of his on that subject was published by the Royal Society in their "Transactions." In 1670 he entered at Jesus College, Cambridge, and here came to know Newton. His observations of celestial bodies continued throughout his undergraduate days, and were directed chiefly to the movements of the moon and the orbits of Jupiter's satellites.

Having graduated in 1674, he was placed on a commission to report upon a proposed method of finding the longitude at sea, and his work in this matter led to his appointment by Charles II., in 1675, as astronomical "observator." His instructions were to study the motions of the heavens and the places of the fixed stars, with a view to perfecting the art of navigation. An observatory, designed by Sir Christopher Wren, was built in Greenwich Park, and, having been ordained as a clergyman in 1675, Flamsteed took up his work as Astronomer Royal in the following year, at the salary of £100 per annum.

Flamsteed was a man of hot temper, and very difficult to get on with, but he was a scrupulous and hard worker. In the following thirteen years he determined the places of twenty thousand stars, working with very poor instruments. His position was improved, however, in 1689, by the revenues of a living with which he had

CAMILLE FLAMMARION, THE FAMOUS FRENCH STUDENT OF THE HEAVENS, WHO HAS GIVEN ASTRONOMY A LITERATURE

been presented, and he was able to set up a mural arc of seven feet radius, with which more accurate work was possible.

He was for long on very good terms with Halley, to whom he was of much assistance, but their relations were finally severed by a quarrel over the publication of Flamsteed's observations. They were published in 1712, under the title of "Historia Cœlestis," and Flamsteed, who had not brought the work to the completeness which he desired, regarded this publication as an injustice to himself. An amended edition was printed later, part of it being finished before his death, on December 31, 1719, and the rest being satisfactorily completed afterwards by his assistant.

GALILEO

Discoverer of the Laws of Motion

Galileo Galilei was born at Pisa on February 18, 1564. He belonged to a noble family of Florence, whose original surname was Bonajuti, but who took the name of Galilei in 1343. Members of this family had filled many honoured positions in the State, but Galileo's father, Vincenzo de Bonajuti de Galilei, though a cultivated man, a musician, and mathematician, was very poor. He desired, therefore, that his son's studies should be, unlike his own, in branches of learning which might prove materially remunerative, and Galileo, at seventeen years of age, was sent to the University of Pisa to study medicine. Up to this time he had been at school at the monastery of Vallombrosa, and had shown himself not only to be a quick and intelligent scholar, but also to have considerable taste and aptitude for poetry, music, and painting. His advice, even as a youth of seventeen, was deemed by artists of considerable value.

His father, knowing by experience that mathematics were a peculiarly unremunerative form of study, endeavoured to prevent Galileo from becoming versed in them, for already, as a boy, his skill in devising mechanical toys showed that he had inherited considerable ability in this direction. However, early in 1583, Galileo, straying into a lecture on Euclid, became fascinated with the subject, and began to devote all his spare time to it. His own disinclination to pursue the study of medicine, and the difficulty which his father found in paying for his college education, added to the fact that his independent and argumentative disposition made him unpopular with the authorities, resulted in his return, in 1585, to his father's house at Florence. Here Galileo pursued the study of mathematics with ardour, and, in 1589, after several vain attempts to secure a similar position, was appointed lecturer in mathematics at the University of Pisa. His salary was absurdly small—sixty scudi a year, or about £13 of our money. This he supplemented somewhat by giving private lessons.

He was obliged to leave Pisa on account of the storm of hatred aroused by his discovery and teaching of the laws of falling bodies. Aristotle had taught that bodies fall in a time proportional to their weight, but Galileo showed, by dropping various bodies from the Leaning Tower of Pisa, how false this assumption was, and stated the real laws of falling bodies. This discovery is the most important of all Galileo's contributions to science, for upon the laws of motion which he expounded the whole science of kinetics, as now understood, virtually rests. But it lost him favour and position, so unwilling were the mathematicians to be convinced by demonstration against accepted authority.

The next year, 1592, Galileo was appointed professor of mathematics at Padua University for six years, and this appointment was twice renewed, so that he retained the position until 1610. In 1597 he invented his proportional compasses, the earliest representative of the sextant.

In 1604 the appearance of a brilliant new star in Serpentarius gave Galileo the opportunity of launching his shafts against the accepted astronomical theories. He attacked first of all the Aristotelian teaching, universally held at that time, as to the unchanging and incorruptible character of the heavens; and proceeded, with all the fervour and probably much of the bold assumption of the new convert, to set forth the Copernican system of the heliocentric universe, and to repudiate the Ptolemaic or geocentric system. In 1609, hearing of the invention of a Dutch optician for bringing distant objects near, Galileo in one night succeeded in working out the principle, and at once set to work to construct a telescope, and, having produced a satisfactory one, turned it towards the heavens, with results which in his day were truly astonishing. For the first time sunspots came to sight, supplying Galileo with a powerful argument against the doctrine of immutability, and by their movement across the face of the sun indicating his rotatory motion. With it, too, Galileo

discovered Jupiter's satellites, and proved the truth of Copernicus's assertion that, if we could but see them clearly, Venus and Mercury would be found to show phases similar to the phases of the moon. Galileo was triumphant. Overwhelming proof seemed to him to be now provided both against the Ptolemaists and against the supporters of the theory of immutability.

The telescope was Galileo's most famous gift to science, though, indeed, it was not really anything like so important as his discovery of the laws of motion, for the simple reason that the telescope would inevitably have been improved and turned upon the heavens—which was Galileo's share in its discovery—before long, even without him, whereas it is unlikely that the laws of motion would have been truly expounded for some time to come.

It is usually supposed that the Church had set her face utterly against scientific progress, and in particular against Galileo's discoveries; but, however that may be, in the year 1611 Galileo visited Rome, and was received with great honour by Pope, cardinals, and priests. His telescope was set up in the Quirinal garden, the property of Cardinal Bandini, and crowds of curious and interested spectators were allowed to come there and look through it. Trouble certainly, arose, however, when Galileo, always assertive and dogmatic, rendered arrogant by his fame and success, went beyond his own sphere, and maintained that Scripture was on his side. In order to realise how dangerous such an assertion appeared to ecclesiastics to be to the faith of the people, we need to remember the familiar association between the Scriptural accounts and teaching and the accepted Ptolemaic system, which, however scientifically false, still remains descriptively true as a mere explanation of appearances. It is said in defence of the Church that it was ready to listen so long as Galileo confined himself to teaching the Copernican system merely as a hypothetical explanation, which it was for future science carefully to determine by observation and inquiry, but that when Galileo asserted it as absolute truth, and as the real teaching of Scripture, they repudiated and condemned his teaching. The proofs which were at that time adduced in support of the Copernican system were by no means eminently satisfying, and many of them are now known to be false. On such inadequate grounds a theory of the universe was boldly proclaimed to the people which was almost certain to result in undermining their faith, since to the ignorant mind it impugned the authority of Scripture. The Church was not concerned with questions of science still manifestly theoretical; she was deeply concerned in the faith of the people. Hence Galileo got into trouble with the Church. We are told by Dr. Whewell that Galileo was accused before the Inquisition in 1615, but at that period the result was that he was merely recommended to confine himself to his mathematical reasonings upon this system, and to abstain from meddling with Scripture.

Galileo apparently submitted. He undertook to put forward the Copernican theory merely as hypothesis, and for some time he adhered in the letter to his promise. But the irony, clever and biting, with which he wrote showed that an unsubdued hostility chafed within him. He produced a paper on the tides, which for him supplied the strongest argument in favour of the Copernican system, now, of course, known to be quite false. In 1618 three comets appeared, and in 1619 Galileo published his theory of comets, which he regarded as of similar nature with halos and rainbows. At the same time the Jesuit Grassi delivered a course of lectures on comets, explaining them as heavenly bodies, a theory which Galileo violently attacked.

It has been noted by one of his biographers that Galileo never, throughout his whole career, put forward a theory which was not remorselessly and bitterly attacked. This fact is not so astonishing when we consider with what ridicule and violence Galileo himself attacked Kepler's lunar theory of tides and Grassi's heavenly theory of comets, both of which were, in fact true, and with what animosity he carried his war into the camp of his opponents, often without reason or justification.

In 1624 Galileo again visited Rome, and was cordially received, but failed to obtain, as he wished, a reversal of the judgment of the Inquisition. The new Pope, Urban VIII., had, as Cardinal Barberini, been one of Galileo's warmest friends, and the astronomer seems to have expected that all would now go as he wished. He published an ironical discussion of the various theories of the universe, "Il Saggiatore," which the Pope enjoyed, and, rendered over-bold by this success, brought out, in 1632, his "Dialogues" on the systems of the world, in which, under the flimsiest veil, he boldly stated the case for the Copernican system. A supposed insult to the Pope, which

Galileo certainly never intended, told against him. He was tried by the Inquisition, made a formal abjuration, and retired to his villa near Florence, a broken and disappointed old man. He died on January 8, 1642.

SIR DAVID GILL

The Searcher of the Skies from South Africa

David Gill was born in Aberdeen on June 12, 1843, and was educated at Marischal College in that city. His devotion to the study of astronomy developed early, and he constructed an observatory in his father's garden. In 1873 he was put in charge of the private observatory of Lord Lindsay at Dunecht, a post he held for three years. Here he was responsible for all the arrangements of Lord Lindsay's expedition to Mauritius, in 1874, for the observation of the transit of Venus. In 1877 Gill organised a similar expedition to Ascension to observe the opposition of Mars, and, from the measurements then obtained, determined the distance of the sun at 93,080,000 miles. For this valuable work he received the gold medal of the Royal Astronomical Society in 1882.

In 1879 he was appointed Astronomer Royal at the Cape of Good Hope, and from 1881 devoted a considerable amount of time to the investigation of stellar parallax, in which branch of astronomy he has secured more exact results than anyone else has yet succeeded in obtaining.

In 1886 Dr. Gill was responsible, jointly with M. Mouchez, of the Paris Observatory, for bringing about a congress of astronomers to arrange for the construction of a complete chart of the sky by international co-operation. He pointed out the value of photography in this work.

Between 1880 and 1896 Dr. Gill organised and brought to completion a geodetic survey of Natal and Cape Colony. He has also been engaged in several other surveys. In 1907, after occupying the position of Astronomer Royal at the Cape for twenty-eight years, Sir David Gill retired from it.

Many honours have been conferred upon him in recognition of his services to astronomy. In 1896 he was created a C.B., and in 1900 was knighted. He has received the recognition of many European and American learned societies. He took a considerable part in the foundation of the South African Association for the Advancement of Science, and was its first president, in 1903. He has published a number of books on astronomical subjects, written for serious astronomical students, and not for the general public.

EDMUND HALLEY

Predicter of Comets and Manager of Newton

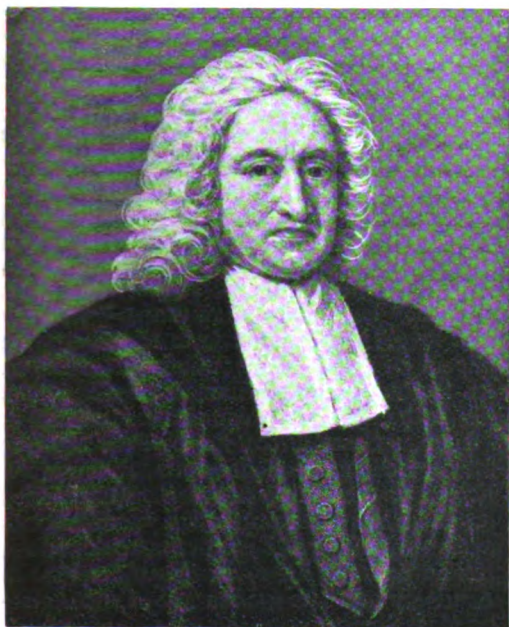
Edmund Halley, the son of a rich soap-boiler, was born in Shoreditch on November 8, 1656. At school he was a brilliant and ingenious student, taking all the honours both in mathematics and classics, and showing interest in astronomy. When he went up to Queen's College, Oxford, in 1673, he took with him telescopes and other instruments, and in 1675 had already contributed to the Royal Society a most ingenious paper on the motions of the planets.

At this time Flamsteed, with the patronage of King Charles, was engaged in making a catalogue of stars, a work in which Hevelius was also occupied. Halley, as a young man of twenty, deeply concerned with planetary motions, was impressed with the value which a similar catalogue of stars in the southern hemisphere would have. Gaining the ear of the King, he procured the means for an expedition to St. Helena, and in 1676 set out to accomplish this design. He succeeded in cataloguing nearly 350 stars, but his work suffered from difficulties of misty skies and an undue precipitancy in his own methods, which sometimes led him to publish results before thoroughly checking them. It was, however, a brilliant feat for a young man. Besides obtaining his catalogue, Halley secured on this journey observations of the variation of gravity in different latitudes, and witnessed a transit of Mercury. In 1678, on his return, he was made a Fellow of the Royal Society, and received the M.A. degree of Oxford by special command.

In 1680, travelling to the Continent with a friend, Halley saw the Great Comet, and, proceeding to Paris, made observations of its orbit with Cassini. This was not the comet associated permanently with Halley's name; that appeared in 1682.

In 1681 Halley was in Italy. In 1682 he settled in London. His time now was chiefly devoted to studying the moon's orbit, and after two years of continual observation he was able to show a cycle of irregularities. In 1685 he became assistant secretary to the Royal Society, and retained this position until 1692. During these seven years he edited the "Philosophical Transactions" of the society, and contributed papers dealing with a wide range of scientific subjects. A few examples will show the variety of his interests: "Historical Account of the Trade Winds and Monsoons"; "An Account of the Circulation of the Watery Vapours of the Sea, and of the Cause of

Springs"; "Discourse Tending to Prove at What Time and Place Julius Cæsar Made His First Descent upon Britain"; "New and General Method of Finding the Roots of Equations."

Perhaps the greatest, and certainly one of the most admirable, of all Halley's gifts to science was, paradoxically, the gift of Newton's "Principia." It is very doubtful whether, without him, this work would ever have been given to the public, for Newton himself was exceedingly diffident respecting his productions. It was Halley who presented to the Royal Society an account of Newton's work, and he was deputed by the society to "jog Newton's memory" to keep his promise of producing the book for publication; and, finally, it was from Halley's pocket that the expenses of bringing it out were defrayed. As Dr. Glaisher said: "He paid all the expenses, he corrected the proofs, he laid aside all his own work in order to press forward to the utmost the printing. All his letters show the most intense devotion to the work."

EDMUND HALLEY

In 1698 Halley had become greatly interested in the variations of the compass, and he obtained from William III. the command of a war-sloop, in which he cruised until 1700, and in 1701 published the results of his investigations in a "General Chart" showing these variations at a glance.

In 1701 he cruised in the English Channel, making a survey of the tides and the coasts. Then followed, in 1702, an exploration of the harbours of the Adriatic. He had the use of the same sloop on each occasion, the "Paramour Pink."

In 1703 Halley was appointed Savilian Professor of Geometry at Oxford, a position which had been refused to him in 1691, on account of supposed atheism. He now published editions of Apollonius and other ancient writers, and edited a repudiated edition of Flamsteed's "Historia Cœlestis."

In 1705 Halley presented to the Royal Society a paper containing his famous prediction of the return of the Great Comet of 1682 in a period of about seventy-six years. He had succeeded in identifying it with the comets of 1531, 1607, and 1682. This prediction was duly fulfilled in the return of "Halley's Comet" in 1758.

In 1721 Halley was made Astronomer Royal, on the death of Flamsteed. Although then sixty-four years of age, he at once entered on a minute study of the moon's motion, which extended over a period of sixteen years. This work was valuable, but it has been suggested that so absorbed a devotion to observation of this particular kind is hardly consonant with the duties of an Astronomer Royal. However that may be, it is certain that Bradley, on his accession to the office, found the instrumental department of the Royal Observatory in hopeless confusion. The lunar tables embodying the results of this protracted study were published in 1749, after Halley's death. Other subjects of his investigations were connected with the orbits of Jupiter and Saturn; the proper motion of the stars; the acceleration of the mean motion of the moon; and his prediction of the circumstances of the total eclipse of the sun which took place on May 2, 1715. In the same year there was a splendid display of the great aurora, of which Halley took careful observations.

In 1729 Halley was elected a member of the French Academy of Sciences. He died at Greenwich on January 14, 1742

SIR WILLIAM ROWAN HAMILTON
Who Applied Mathematics to Astronomy

William Rowan Hamilton, who became professor of astronomy in Dublin, director of the Observatory there, and Astronomer Royal for Ireland, was born in Dublin on August 4, 1805, the son of a Scotsman who had settled in Dublin early in life and practised as a solicitor in that city.

The child was one of the most remarkable examples of precocity of whom there is any

record. He was early encouraged to study languages, with the result that at the age of seven years he could read Hebrew, and five years later his accomplishments included French, German, Italian, Spanish, Latin, Sanskrit, Arabic, Syrian, Persian, Hindustani, and Malay. But he early deserted these linguistic studies for mathematics, in which he showed an even more astonishing genius. Having entered Trinity College, Dublin, in 1823, he secured a strange variety of prizes, including that for English verse. In the following year his first mathematical essay, entitled "A Memoir on Caustics," read before the Royal Irish Academy, won high praise from Sir John Herschel. His appointment as professor of astronomy dated from 1827, and he was made Astronomer Royal shortly afterwards. He was knighted in 1835.

Sir William Hamilton was an excellent astronomer, though he did little work in original observation of the stars. His lectures were clear, and were noted for their consummate eloquence, for Hamilton was a master of language, keenly interested in poetry, and a friend and correspondent of Wordsworth and Coleridge. His great reputation was gained by his work in the most abstruse departments of mathematics, and particularly in the subject of quarternions. His "Lectures on Quarternions" were published in 1853. Sir William Hamilton, who was an extremely popular man, died on September 2, 1865.

SIR JOHN HERSCHEL
A Tireless "Sweeper of the Heavens"

John Frederick William Herschel was born at Slough, "under the shadow of the great telescope," on March 7, 1792. He was the only child of Sir William Herschel, and this fact may be said to have shaped his life. Astronomy was not a natural bent with him, but he was born into an astronomical inheritance. His pursuit of this science was a realised devotion to his father. Yet it not only became a joy to him but crowned his life with brilliant success, such as he could hardly have attained without it. His own interests and powers were very wide and great, but tended to become discursive. It was the strong moral purpose of this filial devotion which concentrated them to such splendid issues.

A genius for practical experiment marked him from early childhood, and as a small boy he was to be found among the carpenters in his father's workshop. But he was a sensitive and delicate child; and his mother, visiting him during his first term at Eton, saw that he was unfitted for public school life, and took him home. He was educated by a tutor until he went to Cambridge, where he entered St. John's College in 1809, and in 1813 graduated as Senior Wrangler and first Smith's Prizeman, and was made a Fellow of his college.

At Cambridge, Herschel and his friends Babbage and Peacock, in furtherance of their compact to "leave the world wiser than they found it," started the Analytical Society of Cambridge, and undertook to reform the teaching of mathematics according to the system already introduced on the Continent. They succeeded, and Herschel pursued the study of pure mathematics so far as to contribute several brilliant papers on mathematical subjects to the Royal Society, and for this work he received the Copley medal in 1821, but about that time he abandoned the subject.

Sir William wished his son to enter the Church, but the lad had no inclination for it, and in 1814 was enrolled as a student at Lincoln's Inn. But science soon reclaimed him from the study of law. Physics, and especially the science of light, had at all times a powerful attraction for him. "Light," he said in later years, "was my first love," and from time to time he wrote papers of great value upon this subject. In September, 1816, Herschel finally joined his father in his astronomical work at Slough, and set about the task of revising Sir William's catalogue of double stars. From 1821 to 1823 this work was carried on with Mr. (afterwards Sir James) South at Southwark, and the results obtained for the authors the Lalande prize of the French Academy and the gold medal of the Astronomical Society.

On the death of his father, in 1822, Herschel took upon himself as a sacred charge the special objects of Sir William's studies and observations. The double stars, the nebulæ, the "sweeping" of the heavens, were for him a labour of love. In 1825 he set to work on a review of the 2500 nebulæ of Sir William Herschel's catalogues, and pursued his task with so much energy that it was completed in about half the time that it was expected to take, and the results were presented to the Royal Society in 1833. This memoir was of immense importance, not only because Herschel possessed at that time the only instrument capable of showing many of these objects, and his observations included over five hundred nebulæ which had never been seen

before, but also because it contained much profound speculation upon the nature and relations of nebulæ. It was illustrated by many careful drawings. While working at the nebulæ, Herschel had also discovered over three thousand double stars, but many of these would now be rejected as too far apart to be true binaries.

In 1829 Herschel married Margaret Brodie Stewart, daughter of a Ross-shire minister. Their life was extremely happy, and pervaded by the sunshine of success. There was an ease and simplicity about John Herschel's life which reflected the ease and simplicity of his character and genius.

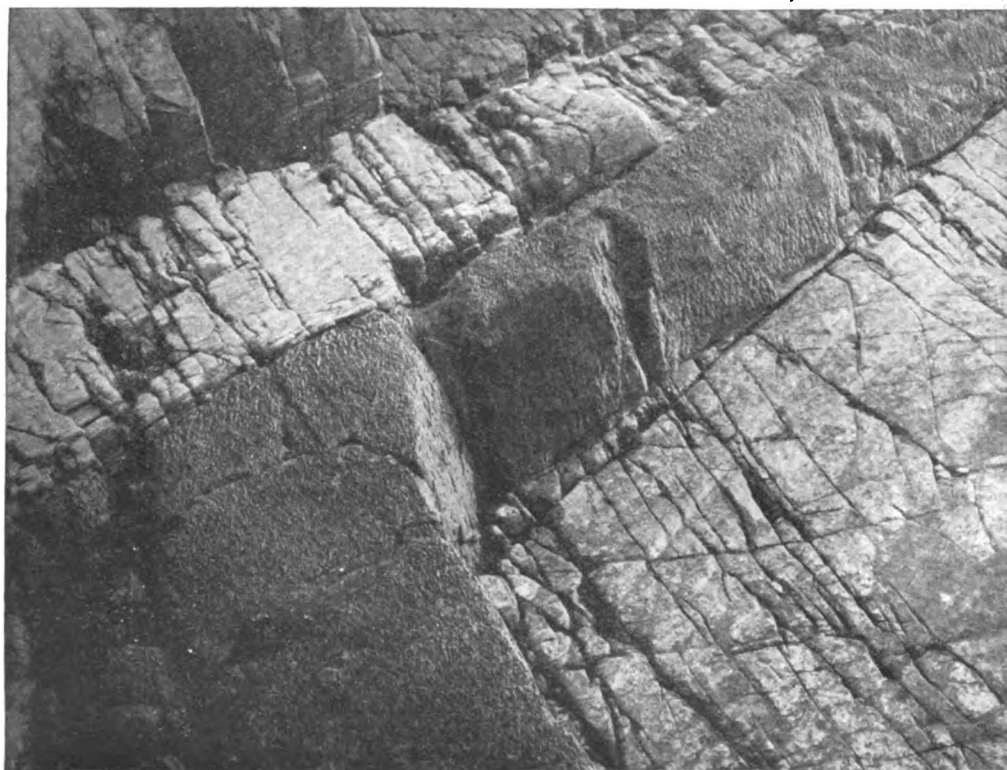
Having verified and supplemented his father's observations of double stars and nebulæ, Herschel took his instruments and family to the Cape, in 1833, in order that he might extend the "sweepings" of the heavens to the southern hemisphere. For four years he remained at Feldhausen, six miles from Cape Town, in a most beautiful and advantageous position. It was the happiest time of his life. All his heart was in the work, and he accomplished an almost incredible amount. The survey of the southern heavens was completed, and many special detailed observations of great value were made. During this time Herschel observed 1202 double stars and 1708 nebulæ, most of them being new discoveries; the Magellanic Clouds; the Milky Way; Halley's Comet; sunspots, and other celestial phenomena. In every case he added not only invaluable stores of observation, but also very enlightening discussions. His catalogue of nearly five hundred stars in order of brightness, according to the "method of sequences" suggested by his father, linked together stars of the northern and southern hemispheres in a single chain, and introduced a definite ratio of magnitude. Herschel returned to England in 1838, but never again took up observational work; he set himself instead to the task of arranging and publishing the materials already collected. The results of the Cape visit were published in 1847. Honours of every kind were heaped upon him; he was elected a member of many great foreign learned societies; he was created a baronet at Queen Victoria's coronation; in 1845 he presided over the meeting of the British Association. But he disliked publicity and only longed for seclusion and hard work.

In 1840 Sir John Herschel removed from Slough to Collingwood, a country house near Hawkhurst, in Kent. Here he remained for the rest of his life, with the exception ot a period spent in London as Master of the Mint, between 1850 and 1855. The routine of official duties and London social life were equally uncongenial to Herschel, and he retired in 1855 to the country, his family and his garden, with great satisfaction. He devoted the remaining years to the revision of his own and his father's observations; published in 1864 the "General Catalogue of Nebulæ," a monumental work which still retains authority as a standard guide; and in 1867 a general list of double stars. He did not live to give to the latter the comprehensive and descriptive character which he had desired. He died at Collingwood on May 11, 1871, and was buried near Newton in Westminster Abbey.

SIR JOHN HERSCHEL

Sir John Herschel's services to science were by no means limited to his astronomical observations and deductions, valuable though these are. His studies in optics led the way to great advances in photographic processes and in spectroscopy. He was the first to use sensitised glass plates, and the first to attempt spectral photography. As early as 1827 he ardently supported the undulatory theory of light put forward by Young and Fresnel, and secured for it general acceptance by an article in the "Encyclopædia Metropolitana." We have already referred to his work in pure mathematics. His "Outlines of Astronomy," a book at once popular and of scientific value, was published in 1849, and has been widely translated.

THE ACTION OF FIRE AND PRESSURE ON ROCK

A BAND OF COARSE PEGMATITE CUTTING GNEISS NEAR LOCH LAXFORD, SUTHERLANDSHIRE

A CLEAVED LAMPROPHYRE DYKE IN KILCHIARAN GRITS, NEAR PORT CHARLOTTE, ISLAY

The study of fire-formed rocks is the chief contribution of Mr. Alfred Harker to the science of geology

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GEOLOGISTS

ALFRED HARKER
An Investigator of Fire-Formed Rocks

Mr. Alfred Harker was born at Hull, on February 19, 1859, and graduated at St. John's College, Cambridge, of which he is a Fellow. He is also Lecturer in Petrology in the University of Cambridge. He was for ten years on the Scottish Geological Survey, and during that time made a searching investigation of the Western Highlands, and drew geological maps of the islands of Skye and Rum, which present some of the most complicated and interesting volcanic structures in the world. In 1907 he was awarded the Murchison medal for his contributions to the studies of petrography and structural geology, and especially for his work on cleavage, and for his investigations of igneous rocks in North Wales and the Lake District.

Mr. Harker has long been advocating a more historical or evolutionary method of studying the details of petrography. To quote his own words, " Instead of applying the knowledge of processes now going on around us to elucidate the record of past ages, we must seek rather to use the history of the past to explain the phenomena of the present." But this method of studying petrography has, in fact, only become possible within very recent years.

Mr. Harker's work on igneous rocks has given a profounder meaning to the whole study of igneous action. He has emphasised the fact that superficial outbursts of igneous material are not the most important phenomena. " Igneous action," he says, " in its dynamic aspect, consists in the moving of a body of magma from one situation to another, in response to differences of fluid pressure ; but whether or not some part of the magma is forced out of the surface depends upon conditions of the second order of importance."

His most important publications are " Petrology for Students," 1895 ; " The Tertiary Igneous Rocks of Skye," 1904 ; and, more recently and generally, " The Natural History of Igneous Rocks."

JAMES HUTTON
The True Father of Modern Geology

James Hutton, one of the greatest of geologists, was born in Edinburgh on June 3, 1726, and, after passing through the Royal High School and Edinburgh University, proceeded to study medicine in Paris and Leyden, graduating in the latter city in 1749. He was the son of a prosperous Scottish merchant and landowner, and, having by his father's death succeeded to a considerable independence, settled down as a Berwickshire laird, and devoted himself to the study of agriculture, geology, and chemistry. Edinburgh was in the eighteenth century actually a metropolis, with a keen intellectual and social life of its own ; and Hutton, who took up his residence there in 1768, became one of its most illustrious figures.

His geological investigations were made chiefly in Scotland, and, indeed, in the vicinity of Edinburgh, but included also journeys throughout England, France, and the Low Countries. By close study of detail and incessant meditation he arrived at profound conclusions which transformed geology from a mere description of the rocks and their relations into a historical study of vast secular processes. That is to say, he introduced the conception of world-evolution into geology, and is therefore rightly regarded as the founder of the modern science. He was also remarkable among his contemporaries, who were too easily swayed by controversy, for a patient and modest attention to the actual facts. Indeed, his greatness probably depends much upon the fact that he neglected controversy, was in no hurry to publish, and was indifferent to fame.

It was not until 1785, when he was nearly sixty years old, that Hutton read

before the Royal Society of Edinburgh his essay entitled "The Theory of the Earth," and the paper was not published until three years later, when it appeared in the "Transactions" of the Society. Indeed, it was only at the repeated request of his friends, who had wandered with him throughout the Lothians, that he took the trouble to give his conclusions to the world. Even when it was published "The Theory of the Earth" failed to receive attention until an Irish geologist slated it in the ruthless fashion characteristic of the period, and stung Hutton into literary activity. He worked up the "Theory" into readable form, adding his more recent corrections and observations, and published it as a separate work in Edinburgh, two years before his death there, in 1797.

"The Theory of the Earth" traces the supposed history of our planet from an epoch when waters covered the present continents, and the clays, limestones, and sandstones of our now visible rocks were being laid down upon the ocean floor. Below these secondary or sedimentary rocks were primary rocks such as granite, which in places also rose above the ocean to form islands. Hutton seeks to discover what forces can have compacted these soft sediments into hard rocks, and then have thrust them above the surface of the waters so as to constitute the land as we know it; and finds that the great internal heat below, and the enormous pressure of the ocean from above, have melted and compressed the loose sediment into rocks. It was the expanding power of heat, also, which drove these rocks upward to form new continents, rending them and tilting them to all angles in the process, while molten material was forced into their fissures from below, or escaped in volcanic eruptions. He discusses also the animals and plants of the earlier continents, of which abundant remains are preserved in fossil form, regarding them as representing the species from which our extant forms of life must have originated. Moreover, he explains the work of frost and sunshine, wind, rain, and stream in weathering and wearing down the elevated rocks, and in thus modelling the surface features of the land. It will thus be evident that James Hutton was a prodigious pioneer. Many of his conclusions have been revised by later knowledge. That was inevitable. But the fact remains that he was the sole founder of modern dynamical geology. From being a static science, it became in his hands a science of change and of process. "We find no signs of a beginning," he said; "no prospect of an end."

It is fitting that the work of John Playfair should be mentioned here rather than separately, for Playfair's work as a geologist—he was an excellent mathematician also—was chiefly summed up in his brilliant exposition and defence of Hutton's great constructive synthesis. He was far from being a mere exponent at second hand; he had great powers of observation and speculative insight, and as the intimate companion of Hutton's rambles had learned himself to use the master's method. For example, it was Playfair who originally suggested that isolated boulders, of constitution differing from the rocks where they are found, have been transported and deposited by moving ice; and again, publishing seven years after the date of "The Theory of the Earth," and five years after the death of his friend, he was able in many respects to develop Hutton's principles. John Playfair, whose "Illustration of the Huttonian Theory" appeared in 1802, was a son of the manse, born at Benvie, a village west of Dundee, in 1748, and, having entered the Church of Scotland, became minister, in 1773, of his native place. He was appointed Professor of Mathematics in Edinburgh University in 1785, holding the chair jointly with Adam Ferguson, and, twenty years later, exchanged that position for the Chair of Natural Philosophy. His annual vacations, which in Scottish universities until quite recently extended over the best six months of the year, were devoted to geological travels in the British Isles, and occasionally throughout various parts of Europe. He died in Edinburgh in 1819.

JOHN JOLY

An Original Student of Radio-Active Energy

Professor Joly was born in Ireland in 1857, his father being the late Rev. P. S. Joly, of Hollywood, King's County, and his mother Julia, daughter of Frederick, Count de Lusi. He graduated at Trinity College, Dublin, to which he returned in 1897 as Professor of Geology and Mineralogy. Between 1882 and 1891, Mr. Joly was Demonstrator in Civil Engineering in Dublin, and from 1893 to 1897 Demonstrator in Experimental Physics.

Professor Joly has devoted much time to the study of radium, and has investigated its distribution in igneous rocks, in

sediments of different kinds, and in various waters. In a work which has attracted a great deal of attention, entitled "Radio-Activity and Geology: an account of the influence of radio-active energy on terrestrial history," Professor Joly deduces most important consequences from the distribution of radium. He believes the influence of radio-activity to be very great in the processes of sedimentation, upheaval, erosion, and the like; it is the energy which "determines the place of yielding and upheaval, and ordains that the mountain ranges shall stand around the continental borders."

Professor Joly estimates the age of the earth at far less than is generally accepted; and in two or three other points his conclusions are questioned by many geologists. His work opens up questions of great interest which point to new fields of investigation.

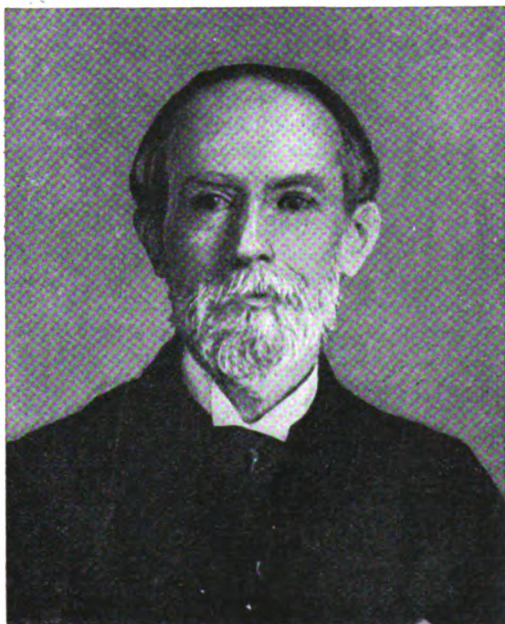
Professor Joly is the author of many papers contributed to the Royal and other learned societies. He is a Fellow of the Royal Society and of the Geological Society, Vice-President of the Royal Dublin Society, and a Commissioner of Irish Lights.

JOHN WESLEY JUDD

From the Schoolmaster's Desk to the Professorial Chair

Professor Judd was born in Portsmouth on February 18, 1840, and at the age of seven years was brought to London, where his father had been appointed to official work at Somerset House. From his earliest years the boy delighted in the study of Nature, and even in childhood contrived to make a telescope with which he observed the stars. After attending school at Camberwell, he decided to become a teacher, and entered a training college for that purpose in 1858. In the following year he went up for an examination, held by the Department of Science and Art, in the sciences of geology and mineralogy, and the excellence of his work brought him an invitation from the examiners to enter the Royal School of Mines for further studies. But he was forced to earn his living, and became master of an elementary school at Horncastle, in Lincolnshire, where he remained three years, and made a geological study of the surrounding country.

In 1863, however, we find him attending the lectures at the Royal School of Mines, where he won an Exhibition; in 1864, as analytical chemist to a steel foundry in Sheffield, where he was introduced by his friend Dr. Sorby to the microscopical study of rocks—then a novel method; and shortly afterwards the victim of a railway accident, from which he barely escaped with his life. Under medical orders to live out of doors and avoid any fixed employment, Mr. Judd returned to Lincolnshire to continue his geological investigation of the country, taking occasional journeys to the Continent to study strata similar to those at home.

It was at this time that Mr. Judd laid the foundation of his great geological reputation, by demonstrating the relations of certain Lincolnshire strata with those of the Continent, and by discovering that the belt of the Oolitic limestones which passes southward from Yorkshire to the Midlands is not of the Great Oolite age, but Inferior Oolite.

ALFRED JOHN JUKES-BROWNE

In consequence of this work he received, in 1867, a post on the Geological Survey, and his researches in that service threw much new light on the Midland strata. Having left the Survey in 1871, he worked for about a year with Matthew Arnold as inspector of schools, and then returned to geology, taking up this time the Jurassic strata in the north-east of Scotland, and the volcanic rocks of the Western Isles. His studies showed the close relationship of many igneous rocks which were before supposed to be sharply distinct from one another, and also revealed the existence of five great sites of Tertiary volcanoes in Scotland.

Mr. Judd's researches in the islands of the

Western Scottish coast brought him the friendship of Darwin, Lyell, and others; and in 1876, on the retirement of Sir Andrew Ramsay to become Director of the Geological Survey, Mr. Judd was appointed Professor of Geology in the Royal School of Mines. The geological department of the school was transferred a year later to South Kensington, where Professor Judd inaugurated a thorough system of practical teaching in the science, and continued to lecture until his retirement in 1905.

His contributions to the literature of geology are very numerous, and cover practically every department of geological inquiry; and he is revered as a teacher by hundreds of students all over the world.

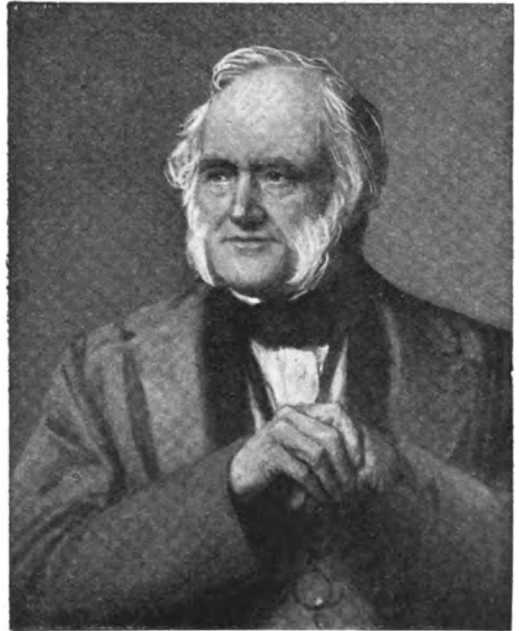
ALFRED JOHN JUKES-BROWNE
A Builder Up of Geological Knowledge

Mr. Jukes-Browne, a nephew of J. B. Jukes, formerly Director of the Geological Survey of Ireland, was born in April, 1851, at Penn Fields, near Wolverhampton, where his father then practised as a solicitor, afterwards removing to Highgate, London. From early boyhood he had marked scientific interests, and collected shells, fossils, and minerals. After a classical education at Cholmondeley School, at Highgate, and later attending lectures in London, he went up to St. John's College, Cambridge, where his tutor was the Rev. T. G. Bonney. Having graduated in 1873, he was in the following year appointed to the Geological Survey of England, and from this time until 1883 was chiefly employed in mapping parts of Suffolk, Cambridge, Rutland, and Lincoln, contributing to memoirs published by the Survey, and writing papers, some of which were published in the "Geological Magazine," and others by the Geological Society. During this time he spent the winter of 1876-7 in Egypt, whence he brought back a collection of small flint implements from Helwan, and gave it to the British Museum.

In 1884 he was entrusted with the preparation of a monograph on the Upper Cretaceous rocks of England, and for this work examined the Cretaceous districts of Herts, Bedford, Buckingham, Oxford, Berks, Wilts, Dorset, and Devon. The results were published in three volumes by the Geological Survey. Owing to impaired health, Mr. Jukes-Browne spent the winter of 1888-9 in Barbados, where, with the assistance of Professor J. B. Harrison, he collected much information about the geology of the island, resulting in the joint production of a map and memoir for the island Government, and two joint papers in the "Journal" of the Geological Society.

Mr. Jukes-Browne retired from the Geological Survey in 1902, and has since resided at Torquay, devoting himself to local geology and conchology. He was awarded the Murchison medal by the Geological Society in 1901, and was elected F.R.S. in 1909. He is author of the following books: "Students' Handbook of Physical Geology" (two editions); "Students' Handbook of Historical Geology," 1889; "The Building of the British Isles," third edition, 1911; "Stratigraphical Geology," second edition, 1912; "Geology," in Whitaker's Series, 1893; and "Hills and Valleys of Torquay," 1907.

SIR CHARLES LYELL
The Champion of Slow Change as the Cause of Stupendous Results

Charles Lyell, eldest son of a wealthy and cultivated man, who had some reputa-

SIR CHARLES LYELL

tion as a botanist, and was also a translator of Dante, was born at Kinnordy, in Forfarshire, on November 14, 1797. While he was quite an infant the family came south to settle at Bartley Lodge, between Southampton and the New Forest, and here, except for occasional summer visits to Kinnordy, the ten children were reared. Charles was sent to school at Ringwood, then at Salisbury, and later at Midhurst

in Sussex, and during these years showed no remarkable attraction to geology, although, like many boys, he was fond of natural history. But almost as soon as he had entered at Exeter College, Oxford, and began to attend lectures upon geology, the interest which was to dominate his life developed. It soon became all-absorbing. In his first Long Vacation he crossed Scotland from Forfarshire to Oban, and visited Staffa and Iona; and in the following year travelled with his parents through France, Switzerland, and the North of Italy, his journal showing everywhere close observation. Graduating in 1819, he began to study for the Bar, but after a few months a weakness of the eyes caused considerable interruption of his legal training, and he was thrown back upon outdoor life and geology.

Having ample means and an indulgent and sympathetic father, he was able to follow wherever his inquiries led. In 1820 and the following years he studied chiefly the South Coast of England, and in 1823 read two papers to the Geological Society, of which he was elected a secretary. In the same year he was received in Paris by some of the leading scientific men, such as Cuvier and Humboldt. In 1824 he travelled widely in the West of England and in Scotland; and was called to the Bar in 1825, and for the next two years went on the Western Circuit and held a few briefs. There his connection with legal practice ended. He was now writing for the "Quarterly Review," and the design of a great work on geology was already clearly in his mind. In 1828, together with Murchison, he travelled to the wonderful plateau of the ancient volcanoes of Auvergne; and thence they worked their way through the Riviera down to Milan and Padua, and Lyell went on alone to Naples and Sicily.

At every step Lyell found confirmation of the principle which was to be the subject of his famous book. He proposed to show, by amassing and setting in order a great volume of evidence of the most various kinds, that the same agencies which are seen at work at present are those which produced the great geological features of the past. His leading idea was that all geological processes are gradual and continuous, and not catastrophic. He announced in a letter to his father that he did not despair of *proving* "the positive identity of the causes now operating with those of former times." The theory, with the overwhelming evidence which he had gathered, was discussed with friends in Paris, and warmly debated in the Geological Society of London, and opinion was sharply divided upon the matter.

In 1829 and 1830 we find him hard at work on his book "Principles of Geology: being an attempt to explain the former changes of the earth's surface by reference to causes now in operation." The first volume appeared in 1830, the second in 1832, and the third in 1833. The book had extraordinary success; it went through many editions; and to the end of his life Lyell was engaged in amplifying and correcting it, often rewriting whole sections. Freeing himself from the tedious obscurity with which scientific writers were and are too often content, Lyell had written a truly popular work, with immense advantage to the future of the science. Indeed, though Lyell was himself no great discoverer, Charles Darwin was able to say that "the science of geology is enormously indebted to Lyell—more so, as I believe, than to any other man who ever lived." His contribution to science is thus summed up by Professor Bonney, his biographer: "Lyell did not claim to have discovered the principle of uniformity. He tells us himself what had been done by his predecessors in Italy and in Scotland, but he scattered the mists of error and illusion, and placed the idea upon a firm and logical basis."

As the leader of the modern science against the unscientific catastrophal geology, which depended partly upon the stupendous magnitude of the phenomena, but still more upon a falsely devout adherence to the Mosaic cosmogony, Lyell must be regarded as the true follower of James Hutton. The idea of uniformity of processes was known already, but it had not made its great challenge. "The Huttonians," says Sir Archibald Geikie, "held that the geological record does not go back to the beginning, and that therefore any attempt to trace that beginning from geological evidence was vain. Most strongly, too, did they protest against the introduction of causes which could not be shown to be a part of the present economy. They never wearied of insisting that to the everyday workings of air, earth, and sea must be our appeal for an explanation of the older revolutions of the globe. The fall of rain, the flow of rivers, the slowly crumbling decay of mountain, valley, and shore, were one by one summoned as witnesses to bear testimony to the manner in which the most stupendous geological

changes are slowly and silently brought about." Lyell's work was to elevate that principle, from being the theory of a school of geologists, to become the unquestioned and fundamental principle of the science.

In 1831 Lyell had been appointed Professor of Geology at King's College, London, but soon gave up that position in order that he might devote himself entirely to research. His marriage, in 1832, to Mary, daughter of Leonard Horner and niece of Francis Horner, both of whom were enthusiastic geologists, was an exceedingly happy one, although no children were born of it. Lady Lyell—for her husband was knighted in 1848, and later received a baronetcy—was deeply interested in his work, and accompanied him on many of his travels. These were numerous and extensive. In 1834 he was in Denmark and Sweden, and visited Norway in 1837. His "Travels in North America," published in 1845, contains an account of twelve months spent in Canada and the Eastern States in 1841; and his journey to the Southern States in 1845 was chronicled in "A Second Visit to the United States of North America," published in 1849 He was twice again in America in later years, and voyaged also, in 1854, to Madeira and the Canary Isles. Together with his wife he travelled often in various parts of Europe.

Sir Charles Lyell was a friend and correspondent of Charles Darwin, and was one of the first to accept with enthusiasm the doctrines published in "The Origin of Species." He died on February 22, 1875, and was buried in Westminster Abbey.

SIR HENRY ALEXANDER MIERS
A Student of Minerals

Sir Henry Miers, Principal of the University of London, was born at Rio de Janeiro on May 25, 1858, the son of Francis Miers, C.E. He was educated at Eton and Trinity College, Oxford. In 1882 he became an assistant at the British Museum; in 1886 instructor in crystallography at South Kensington Technical College; and held both of these positions until 1895, when he was appointed Waynflete Professor of Mineralogy at Oxford. His inaugural address was on the subject of Individuality in the Mineral Kingdom. Professor Miers soon rose to a leading position in Oxford, and was secretary to the Delegates of the University Museum, and a member of the Hebdomadal Council.

In 1901 Professor Miers undertook a journey to the Yukon goldfields to study the mining conditions at Klondike, and the auriferous deposits of that region, and investigated the various methods employed for thawing the permanently frozen ground, as well as the social conditions of the rapidly developing mining centre. In 1901 he published "A Visit to the Yukon Goldfields."

The most important work which Professor Miers has written is a book entitled "Mineralogy: an Introduction to the Scientific Study of Minerals," published in 1902, extremely well illustrated. The subject of crystallography is one to which Professor Miers has made valuable contributions. A paper read before the Royal Society, in 1903, describes a new method which he had devised for observing the growth of crystals.

SIR HENRY ALEXANDER MIERS

Appointed in 1908 Principal of the University of London, Professor Miers has been Vice-President of the Chemical Society, and of the Geological Society, President of the Mineralogical Society, and of the Geological and Educational Sections of the British Association, and a member of the Council of the Royal Society.

HUGH MILLER
The Imaginative Explorer of the Old Red Sandstone

Hugh Miller was born at Cromarty on October 10, 1802. His father, a hardy, resolute sailor, died when Hugh was five years old. The boy was put to school, but played truant continually, wandering over the country; or at school he would

distract his companions from their lessons by telling them stories in a spirited manner, which made him early a leader among them. His feeling for Nature was even in early boyhood strong and picturesque. Miller's real teachers were two fine, simple men of middle age, Uncle James and Uncle Sandy, brothers of Hugh's mother. They instructed him in his catechism, and inspired him with a deep devotion to his country, and a love of adventure.

In 1820 Miller apprenticed himself to a mason, "old David Wright." The exposure and the heavy labour told upon him severely the first year, and resulted in long attacks of depression. But his love of Nature rescued him. From a child Miller had delighted in observing the rocks and vegetation, and the small creatures found on the shore at low tide. His first work as a mason's apprentice was in a quarry of sandstone, which showed "a bar of deep red stone beneath, and a bar of pale red clay above. Both deposits," wrote Miller, "belonged to formations equally unknown, at the time, to the geologist." This deep red stone was later to place Miller's name among the eminent geologists of all times. He was at this time drawn to examine it by observing upon its face ripple-marks like those upon the sands at low tide. Still more fascinating was the discovery, about the same time, of the fossil treasures in the Lias beds of the Hill of Eathie. "Who," he writes, "after once spending even a few hours in such a school, could avoid being a geologist? I had formerly found much pleasure among rocks and in caves, but it was the wonders of the Eathie Lias that first gave direction and aim to my curiosity. From being a mere child, that had sought amusement in looking over the *pictures* of the stony volume of Nature, I henceforth became a sober student, desirous of reading and knowing it as a book."

In 1823 Miller completed his apprenticeship, and the next eleven years were spent as a journeyman mason in various parts of the Highlands and Lowlands. All the time he was observing and pondering. In 1824 and 1825 he was at Edinburgh, employed in stone-cutting at the village of Niddrie, and it was in his evening walks around this district that he first came across and studied the Carboniferous system. "The stone at which I wrought was intercalated among the working coal-seams, and abounded in well-marked impressions of the more robust vegetables of the period; and as they greatly excited my curiosity I spent many an evening hour in the quarry in which they occurred, in tracing their forms in the rock." Groping his way with no scientific training, and even "wholly unfurnished with a vocabulary," Miller pursued the study of these formations until "the vegetation of the coal measures began gradually to form within my mind's eye, where all had been blank before, as I had seen the spires and columns of Edinburgh forming amid the fog on the morning of my arrival."

In 1825 Miller had to return to Cromarty, suffering from the stone-cutters' disease; and, though he recovered his health, his lungs were injured for life. He continued his rambles, observing and writing, and recurred to a long-cherished desire for a literary career. Hugh Miller was, indeed, a born writer; and geology owes as much to his pen as to his observations. The power and picturesqueness of his writings had the effect of popularising the science. In 1829 he visited Inverness, and formed a lifelong friendship with Carruthers, editor of the "Inverness Courier," who brought out his "Poems Written in the Leisure Hours of a Journeyman Mason," and, in the same year, the interesting "Letters on the Herring Fishery."

HUGH MILLER

In 1832 Miller became engaged to Lydia Mackenzie Fraser, but was resolved not to marry her so long as he continued to earn his living by manual labour. He determined

to join the ranks of brain-workers, that he might offer her the position of a lady. After much difficulty, great anxiety, and occasional hopelessness, he obtained a position as accountant in a bank at Cromarty, in 1834, and relinquished the mason's life, which had been so "soothing and inspiring." The evenings were devoted to literary work, and in 1835 the results of many years of wandering were published in "Scenes and Legends in the North of Scotland." Geology forms the subject of a chapter; scenery, legends, and character-sketches make up the rest.

As a relaxation from the weary routine of bank business, Miller spent his spare time in exploring the Old Red Sandstone of Cromarty, in which he discovered a wealth of fossil fishes. His studies of Pterichthys were of great importance, and one new member of this family was named after him. At this time he began to correspond with the illustrious Agassiz, and to gather the material which went to form his "Old Red Sandstone." This book, by far his most famous and important, appeared first in serial form in the "Witness," a paper which Miller edited from 1840 to 1856. It was republished in book form in 1841. Before the appearance of this work the fossil remains of Old Red Sandstone were practically unknown; the importance of this formation was at once recognised, and it became the subject of eager investigation. The book is in the style of Hugh Miller at his best. Professor Huxley said of it: "The more I study the fishes of the 'old red' the more I am struck with the patience and sagacity manifested in Hugh Miller's researches, and by the natural insight, which in his case seems to have supplied the place of special anatomical knowledge."

In 1846 Miller published his "First Impressions of England and its People," the results of a holiday necessitated by a breakdown in health. In 1847 came "The Footprints of the Creator," a combination of geology and theology; and in the same year, the results of another necessary holiday, "The Cruise of the 'Betsey' Among the Inner Hebrides." In 1852 he published his autobiography, "My Schools and Schoolmasters," which has become a classic. At the time of his death he was straining every nerve to get his last book, "The Testimony of the Rocks," through the press. Fatigue, strain, and a recurrence of lung trouble proved too much for him, and culminated in insanity. In the night of December 23, 1856, he shot himself.

PROFESSOR JOHN MILNE

The Recorder of Earthquake Tremors Throughout the World

John Milne, the great student of seismology, or the science of earthquakes, was born in Liverpool on December 30, 1850, and after school-days at Rochdale and Liverpool passed on to King's College, London, and thence to the Royal School of Mines, studying to become a mining engineer. After some practical experience in the mining districts of England and Central Europe, he was commissioned to investigate the mineral wealth of Newfoundland and Labrador. This inquiry occupied two years; and then, in 1874, Milne was attached to Dr. Beke's expedition, which was sent out by the Rothschilds to determine the situation of Mount Sinai. He was only twenty-four years of age when he was appointed by the Japanese Government to be consulting engineer to the Public Works Department which they had just founded. Milne conceived the adventurous idea of proceeding to his post by a solitary overland journey across Europe and Asia, and after eleven months of travel, and considerable hardships, arrived at Shanghai in February, 1876.

The first night of his residence in Tokyo was marked by a considerable earthquake, and from that night the young engineer made earthquakes his chief study. They were and are extremely numerous in that country, and at that time resulted in enormous damage, though modifications in the practice of building, due chiefly to Professor Milne's researches, have since greatly mitigated their dangers.

Four years after his arrival, on February 22, 1880, the island was visited by an earthquake of great severity, and Milne made use of the public excitement to impress the claims of seismology upon the nation. His appeal was successful. It resulted in the establishment of the Seismological Society of Japan, which has done a vast amount of good work. The Government appointed an Earthquake Committee, with large funds, to investigate every important shock; and a Chair of Seismology, first occupied by Professor Milne, was founded in the Imperial University.

Both the practical and the scientific results of the novel study which Professor Milne thus initiated have been of capital importance. It has saved an incalculable number of lives, and prevented an inestimable amount of material damage. In the great earthquake which devastated Japan in 1891, nearly ten thousand were killed,

and over one hundred thousand injured; and though these numbers are quite exceptional, the frequent shocks of that region are answerable for a considerable death-roll. Where that is so, the discovery of methods of building houses and bridges which make these structures comparatively immune from the effects of earth tremors is a vast benefit to society. With the scientific results we have dealt fully elsewhere, but it will be remembered that they afford very interesting hints with regard to the constitution of the interior of our globe.

Having spent twenty years in Japan, and visited, besides, many volcanic islands and the principal earthquake regions of the Pacific coast, Professor Milne returned to England in 1895, and settled at Shide, near Newport, in the Isle of Wight. He had married a Japanese lady, and received a distinguished Order and a pension from the Mikado. At Shide he established a highly equipped observatory for studying earthquakes, and from this quiet situation, by means of the delicate instruments which he and other seismologists have perfected, his researches extend over the whole earth. He has been able to promote the establishment of over sixty seismological observatories in various parts of the world, from which he receives regular reports, so that by the comparison of their records the source, the direction, the nature, and the extent of each earthquake may be fully determined. Twice in a year Professor Milne sends out to every seismological observatory a circular giving the registers of all recent earthquakes. Professor Milne has published a great number of papers dealing with every aspect of the subject, as well as the volumes "Earthquakes" (1883), "Seismology" (1898), and "The Miner's Handbook."

SIR RODERICK IMPEY MURCHISON
A Master-Force in Geological Advance

Sir Roderick Murchison was born at Tarradale, near the Beauly Firth, in Ross-shire, on February 19, 1792, was trained for the army, and saw active service in the Peninsula. He had been interested in geology from boyhood, and after his marriage, in 1815, gave his life to that pursuit. After making careful geological studies of Sussex, the island of Arran, and other districts, he travelled in 1828, with his wife and Charles Lyell, to Auvergne, the Riviera, and northern Italy. With Adam Sedgwick, Professor of Geology at Cambridge, Murchison made close investigations of the Bavarian Alps; and in 1831 these two accomplished geologists began the study of the Palæozoic deposits in Wales, which resulted in Murchison's famous work "The Silurian System," published in 1839. A laborious examination of the fossils of Wales and the western English counties enabled him to separate clearly three main subdivisions of the Silurian system—namely, Upper Silurian, Lower Silurian, and Cambrian—a distinction which has been accepted as the basis of all subsequent work on these strata. Murchison and Sedgwick also defined the "Devonian System," from their studies in Devonshire and Cornwall, including in this system the Scottish Old Red Sandstone, as well as many strata of the region of the Rhine. The "Permian System," as a geological distinction, was a result of Murchison's travels in Russia and the Ural Mountains. Unfortunately, Murchison and Sedgwick carried a difference of opinion with regard to the independent identity of the Cambrian system to such a point that their friendship was broken off. Sedgwick insisted that the Cambrian was a separate formation, while Murchison regarded it, after further examination, as being the same as the Lower Silurian. It is now generally admitted that Murchison was in the wrong.

Murchison was one of the pioneers of the "drift" theory, which explained the deposit of boulder-clay, and the transport of large erratic blocks, by the action of icebergs floating southward from Arctic seas. These heavy surface deposits had been formerly regarded, as by Buckland, as the result of the Deluge of the Book of Genesis, and were consequently known as diluvial detritus. In the interval, however, knowledge of the nature and work of icebergs had greatly increased, with the result that the drift theory of Lyell, Murchison, Darwin, and others was for some time regarded as the true explanation of the boulder-clay. But the drift theory has in its turn been long abandoned in favour of the glacial theory, which regards glaciers, and not floating icebergs, as responsible for these deposits, although a few geologists, and conspicuously Professor Bonney, continue to maintain the older view of Murchison, Lyell, and Darwin.

Murchison was a geologist of wide knowledge, and great penetration of mind, and one of the ablest stratigraphers who ever lived. He was also a man of much force of character, whom no obstacles could deter. In 1855 he became Director of the Geological Survey of Great Britain, and a baronet in 1866. He died on October 22, 1871.

SIR JOHN MURRAY

A Reader of the Geologic Lessons of the Sea

Sir John Murray was born in Coburg, Ontario, Canada, on March 3, 1841, the son of a Scottish accountant who had emigrated a few years before, and who took a prominent part in Canadian politics. Educated at first in Canada, John Murray came, at seventeen years of age, to Scotland, and studied at Stirling High School and Edinburgh University. His keen interest in Nature, from childhood, led him during these years to form a large natural history museum, of which many specimens are now at the Macfarlane Institution, Bridge of Allan.

Sir John Murray's scientific work has covered a wide range of subjects, but it has been concerned, for the most part, with the problems of the sea. The structure, history, and deposits of the ocean floor, marine currents and temperatures, the chemistry of sea-water, the origin of coral islands, the movements of polar ice, and the nature and distribution of oceanic plants and animals, are subjects to which he has devoted himself in such a way that his reputation as an oceanographer is the first in the world. At twenty-seven years of age he went to the Arctic seas in a Scottish whaler, visiting Spitzbergen, and attaining the latitude of 81 N., and brought back large biological collections and wide observations on the distribution of the Arctic ice, and on currents, temperatures, and the like.

All this was the best possible preparation for his magnificent "Challenger" work. The expedition of H.M.S. "Challenger," under Captain Nares, with Wyville Thomson as director of the civilian staff, extended from 1872 to 1876 in a systematic exploration of the oceans of the world, which were studied in every scientific aspect. Murray had much to do with the preparation of the expedition, and accompanied it throughout, making a special study of deep-sea deposits and of ocean fauna, and taking charge of all the collections of every kind. When the ship returned to England the Government undertook to publish the results; and in this work Murray was at first chief assistant, and on the death of Wyville Thomson, in 1882, became sole director and editor of the huge work, which fills fifty large volumes. It is a matter of common knowledge that this monument of science would never have been carried to completion except for Sir John Murray's determination, and for large subsidies from his private fortune. Besides editing the whole work, Murray wrote the volumes containing the summary of the scientific results of the expedition, and was joint author of the narrative of the cruise, and of the work on the deposits on the ocean floor. For twenty-four years Sir John Murray continued to hold an official connection with the "Challenger" Expedition, and since the completion of that great enterprise has maintained an oceanographical laboratory and museum in Edinburgh, where much good work has been done. He has founded also marine biological laboratories at Granton, on the Firth of Forth, and at Millport, on the island of Cumbrae, in the Clyde; and by means of his steam yacht "Medusa" has made close scientific investigation of the Scottish coasts. He took part also in explorations of the Faroe Channel, which were made in Government vessels in the years 1880 and 1882; and in 1910 undertook a scientific cruise, of which he bore the cost, in the North Atlantic, together with Dr. Hjort, on the Norwegian fishery steamer, "Michael Sars." The results of the latter expedition were published under the title of "The Depths of the Ocean."

In 1898 Sir John Murray began, together with the late Mr. Fred Pullar, a systematic bathymetrical survey of the Scottish freshwater lochs. On the death of Mr. Pullar, in 1901, his father provided the means for the completion of the survey, under Sir John Murray's direction. Five hundred and sixty-two lochs were systematically sounded, the conformation of their floors being ascertained by as many as sixty thousand soundings, and the results were published in a large work in 1910. It was largely owing to Sir John Murray's scientific enthusiasm that the Ben Nevis Meteorological Observatory, at the summit of the mountain, was opened in 1883, and he remained one of its directors until the observatory was closed in 1904.

Of the honours which have fallen to Sir John Murray we have not space to write; they are numerous and distinguished. He is well known as an ardent educational reformer, regarding personal practical efficiency, and not culture or social amenity, as the true end of education. In this respect he has seen the principles which he advocates coming more and more to the front. He is himself supremely practical. For example, in Christmas Island, in the Indian Ocean, he found a real treasure island, procured its annexation by Britain in 1888, and formed a successful company to work its phosphates. The fact that the Treasury has received more from this island than it spent on the "Challenger" Expedition is, he thinks, an argument for subsidies to scientific work.

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BIOLOGISTS

PAUL ERHLICH

A Great Inventor of Curative Poisons

PAUL EHRLICH was born at Strehlen, in Silesia, on March 14, 1854, and took his doctorate in medicine at the University of Leipsic in 1878. In the course of the present century he has been the recipient of many international honours, to say nothing of the fact that he lives in a street in Frankfort which is called the "Paul Ehrlichstrasse." Since he won the Nobel Prize of Medicine, in 1908, he has made his greatest discovery in practical medicine.

The chemistry of disease, or, as it may well be called, pathological chemistry, is and has always been the subject of the life-work of Paul Ehrlich, who is now Director of the Royal Institute for Experimental Therapeutics at Frankfort. There he has a magnificent institution, specially provided for him, where his astonishing genius and devotion have adequate opportunities.

The essential part of the work of Pasteur had been done when young Ehrlich began his researches. He saw clearly from the first, as indeed all serious students did, that the problems of susceptibility and immunity, of death or of recovery, in cases of attacks of the minute parasites which Pasteur had proved to cause disease were essentially chemical. They involved reactions between the tissues of the host and the substances produced by the invading organisms; and if our understanding of disease was ever to be intimate, and effective for the *cure* of infections, we must attack the details of these immeasurably complex chemical reactions. The simpler theories, such as that of Pasteur himself, were clearly inadequate to explain the production of immunity. That state is not brought about by the exhaustion of a special diet which any species of parasite finds in the tissues. It is a positive, not a negative, state; and the key to its production, under "natural" conditions of disease, should enable us to control disease.

This subject of immunity has chiefly engaged Ehrlich's attention, and his collected papers thereon, published in 1903, are the most notable of all contributions to the subject. By dint of much experiment and his chemical genius, Ehrlich was enabled to devise his celebrated "side-chain" theory of immunity, in which he attempted to express, in terms of chemical molecules, the processes by which immunity is gained, and the conditions under which susceptibility, or lack of immunity, exists. More than a decade has now passed since this famous theory was elaborated, and it holds the field. It needs, and has received, further elaboration, but it has proved its value in that it has led investigators—above all, its own author—along lines of inquiry that have proved fruitful.

Paul Ehrlich's work has always been directed to definite therapeutic ends. He did important service, when the antitoxin for diphtheria was first obtained, in devising means for estimating its value, and standardising it so that it could be safely used by the practitioner. Then, several years later, came the discovery by Schaudinn of the minute wavy translucent organism belonging to the "spirilla," which causes syphilis. This offered a new opportunity for Ehrlich's priceless genius. Almost his first research had dealt with the fashion in which living nerve-cells react to the chemical dye known as methylene blue. To the ordinary student of medicine, the microscopist or neurologist, the fact that a given tissue "stains" with a given substance means no more nor less than that *that* is the substance he uses when he wishes

to study the tissue in question. Such knowledge is, of course, invaluable, as when a particular combination of stains or dyes enables the investigator to pick out and discover the tubercle bacillus, or some other microbe of almost equal importance.

But to a student essentially chemical, like Ehrlich, the fact that a tissue stains with a dye is a chemical phenomenon. It means that the tissue has certain chemical constituents which are capable of holding on to that dye. Indeed, in such an every-day fact as the dropping of a stain upon a section or culture, Ehrlich saw chemical processes which were closely allied to those of immunity, as he had studied it for many years. The tissue in question was "susceptible," so to say, to the dye that stained it. But this, which was convenient for the microscopist who wished to study the architecture of the tissue, might conceivably have large consequences in another connection. Let us suppose that the tissue in question is that of some deadly disease-parasite. Let us further suppose that we have available some deadly poison, such as arsenic, which should quickly kill this parasite, as it will indeed kill any form of protoplasm whatever. If we introduce arsenic into the body of a person in whom the parasites dwell, we find that the parasites are unaffected, though the person may be himself gravely poisoned. The parasites are immune to the poison, not because it is not a poison to them, but because it does not enter their bodies.

Let us now contrive an "amboceptor," to use the name and the idea introduced by Ehrlich many years ago. Let this two-handed substance be such that with one hand it can hold the parasite or some chemical constituent of the parasite, while with the other it can hold the poison. This amboceptor will thus serve as a poisoner, introducing the poison to the parasite, which will forthwith die—and the host or patient will live.

To find or make this hypothetical substance was Ehrlich's task. The amboceptor would probably be some dye which was known to stain—because it entered—the bodies of the spirilla; and perhaps this dye, or its essential ingredient, might somehow be made to combine chemically with arsenic. Then this compound might be given to a patient, so as to kill all the parasites in his body, while he himself would be uninjured, for the arsenic would not injure him, but would be all taken up by the parasites, owing to the action of the amboceptor with which it had been intentionally linked.

Such is an account—too simple, for the facts are excessively complex, but still indicative of the principles involved—of Ehrlich's research. Hundreds of compounds were constructed and tried, unsuccessfully, and the six hundred and sixth substance tried was successful. Its chemical name, indicating its construction and constitution, is "dioxy-diamido-arseno-benzol," and it is usually called "606," or "salvarsan."

Ehrlich hoped that salvarsan, or the substance he sought, would effect a "therapeutic sterilisation" at a single dose, so that the victim of syphilis, acquired or "inherited," might be cured in a few hours, as compared with the two or three years of treatment by mercury. The effects of salvarsan, properly used, have indeed been almost magical in hosts of instances, but this absolute extermination of the parasites seems to fail of completeness in many cases. Professor Ehrlich is not satisfied. He is at present experimenting with another substance of the same type, "No. 914."

HAVELOCK ELLIS
A Master-Student of Sex

Henry Havelock Ellis was born at Croydon on February 2, 1859, and studied medicine at St. Thomas's Hospital, but interrupted his medical curriculum for some years by a period in New South Wales. He took a medical qualification at the age of thirty, and then also began to edit the Contemporary Science Series, one of the most valuable of its kind in any language. He soon abandoned medical practice, and devoted himself to research and writing.

Havelock Ellis is essentially a psychologist of the new type—one who does not attempt to define mind in general from the data of his own consciousness, but one who studies and records the facts of behaviour in as many types of people as possible. His first important work dealt with the criminal from this point of view, and this volume, "The Criminal," was reissued in 1910.

In 1904 he published a valuable volume, called "A Study of British Genius," in which a laborious and discerning attempt was made in the direction of what might be called a natural history of genius in the British Islands. Each of these volumes is invaluable for the modern student of man.

Familiar and indispensable to all students of such subjects is also his book "Man and Woman," in which all the available

literature of the subject is digested and analysed. This comparatively small book is to be looked upon as an addendum to the chief work of the author's life—his "Studies in the Psychology of Sex." This great work, of which the last portion appeared in 1910, consists of six large volumes, the first of which appeared in 1899. The last volume, "Sex in Relation to Society," sums up the substance of the whole.

Ellis saw that sex, though it plays an immeasurable part in our lives, though it matters immensely for nearly all, or all, individuals, and for society as a whole, had never been subjected to serious study by scientific methods and by a student fitted for the purpose. We have many studies of sex, written, for the most part, by literary degenerates describing their own cases, but there had been made no attempt to state, as facts of natural history and psychology, the phenomena of sex and their consequences, their development in the individual, and their anomalies, with all the influence which these have upon the lives of individuals and society. Ellis set himself the immense task of filling this gap in "the proper study of mankind."

To Dr. Ellis and his wife the English-speaking world is indebted for their introduction to the writings of the interesting Swedish Eugenist Ellen Key.

GUSTAV THEODOR FECHNER

A Pioneer of Experimental Psychology

Gustav Theodor Fechner was born in Lusatia on April 19, 1801, and studied at Leipsic, where, at the age of thirty-three, he became professor of physics. There, for several years, he worked at galvanism and the relations between electricity and chemistry. Then, owing to trouble with his sight, he was compelled to abandon physical research, and he devoted himself for the rest of his life to psychology. If we are to understand him we must remember that he came to the study of the mind as a physicist, with the training and the mental habits which that involves.

Fechner was an extremely prolific writer, and was publishing fresh volumes well on in his seventies, but his principal work is his "Elements of Psycho-Physics," which was published in 1860. The researches embodied in this book constitute him the true pioneer in that experimental study of psychology by physical methods which is characteristic of Germany, and has been pursued with unflagging and increasing energy for the last half-century.

The great principle of psycho-physics is, or was, that we can reduce the facts of psychology to mathematical statements as we can reduce the facts of physics. It is, in short, an attempt to contrive a physics of the non-physical, which is of the nature of an absurdity. It was based upon a so-called law which is still often known by Fechner's name—or, more often, as the Weber-Fechner law—but which he himself called the law of intensity. It asserts that the intensity of a sensation increases as the logarithm of the stimulus; or, in other words, that "in order that the intensity of a sensation may increase in arithmetrical progression, the stimulus must increase in geometrical progression." But, on further inquiry, it has been shown that this law is not absolutely true, and breaks down altogether in a large number of instances.

Its author was, however, persuaded into the belief that a mathematics of the mind could now be achieved. He declared that there must be a unit of sensation, as there are units of matter, and that any sensation whatsoever must consist of a certain number of such units. Since sensations are at the basis of psychological analysis, it would seem to follow that, by patient application, we should be able to measure all mental processes and, in the long run, write the formula for the production of "Hamlet," for the heroism of a Jeanne d'Arc, or the tenderness of a St. Francis.

But, of course, such hopes were destined to disappointment. Stimuli are physical things, and can be measured, like all other physical things, but sensations are psychical things, and cannot be measured. Each sensation is not a mere aggregation of a certain number of sensory units. Indeed, there are no such sensory units as Fechner postulated.

It would be very natural to suppose that an author whose view of the mind was so astonishingly mechanical should be, in his view of the world, a materialist, but this was far from the case with Fechner. On the contrary, he was a follower of Spinoza, who argued that matter and mind are different aspects of the one reality; and hence he supposed that our measurements of the physical world ought to suffice as measurements for the psychical world. Fechner is therefore certainly not to be ranked as a materialist, and, indeed, he definitely wrote against materialism and its hopelessness. He died in Leipsic, where he had lived for more than half a century, on November 16, 1887.

SIR DAVID FERRIER

The Man who Mapped Out the Brain

David Ferrier was born at Aberdeen in 1843, and studied medicine first in the university of his native town, and later in Edinburgh, where he took his doctorate in medicine in 1870, with a gold medal for his thesis on the comparative anatomy of the brain. He was appointed to the Chair of Nervous Pathology at King's College, London, and shortly afterwards, in 1876, became a Fellow of the Royal Society. Since that date he has been the recipient of numerous honours at home and abroad, and was knighted in 1911. He was the founder and editor of the valuable scientific journal "Brain." His two principal books are "Functions of the Brain," published in 1876, and "Localisation of Cerebral Disease," published in 1878.

SIR DAVID FERRIER
Photograph by Maull & Fox

Sir David's name will be remembered as that of one of the founders of "cerebral localisation." Paul Broca showed that such localisation was possible in at least one instance, and young Ferrier began his career of research just at the time when the key seemed to hand for the identification of the functions of the various parts of the brain. This was a problem of equal interest for psychology and metaphysics on the one hand, and for remedial medicine and surgery on the other hand.

Ferrier set himself to the examination of the facts as they appear in the lower animals. In man they could only be guessed at, very simply, by the comparison of symptoms observed during life with the particular site and extent of the lesions, or pathological states, found in the brain after death. But there was every reason to suppose that such animals as the monkey and the dog would reveal facts closely parallel to those of man; and at a later date, thanks to the developments of antiseptic and aseptic surgery, it was possible to observe, in the course of operations upon the human brain, that stimulation at such and such points produced contraction of such and such muscles or muscular groups.

Ferrier's results are now classical, for they laid, in the 'seventies of last century, the foundations for all subsequent study of the functions of the brain. Broca had found a motor area for speech. Hughlings Jackson had identified the relation between a certain part of the brain and what we now call Jacksonian epilepsy. Ferrier then set to work, studying the brain of the ape. After the animal had been rendered unconscious and insensible to pain by means of an anæsthetic, the skull was trephined in exactly the same fashion as is daily employed in operations upon human patients; the brain was exposed, and then Dr. Ferrier observed the results of stimulation at various points by means of a couple of blunted platinum wires conveying a small current of faradic electricity. The electrodes, or blunted wires, were applied to the brain at a distance of only one-eighth of an inch apart, and the feeblest possible current was used, so that as minute an area of the cortex as possible should be stimulated at a time. By subtly contrived electrical indicators of nervous currents it could be shown that the stimulation acted upon the cortex itself, and not upon the white matter of the brain. In this fashion it became possible to map out the various areas upon the outer and inner surface of the cortex in the ape; and the clinical application of these results in man has been eminently trustworthy.

The early results, obtained nearly forty years ago, are now obsolete, so much further work having been done in the interval. The surgeons especially have had opportunities of observing the facts in man himself. Also, other methods of inquiry have been employed, such as the observation of the order of development of different parts of the brain. But Sir David Ferrier's pioneer work was indispensable, and none

the less so because he and his successors found such large areas of the brain where no stimulation produced any effect whatever. These "silent areas" are particularly characteristic of the human brain.

Sir David has lived to see the practical limit of the "new phrenology," of which he was the experimental founder. Centres for motion and sensation can now be accurately defined; but no tests employed or imaginable will discern centres for any of the higher functions of the mind, which elude electrodes and the microscope alike

NIELS FINSEN
Discoverer of the Healing Power of Light

Niels R. Finsen, the discoverer of the medical powers of the chemical rays of light, was born in the Faroe Isles in 1861, and after a brilliant career at the University of Copenhagen became teacher of anatomy there. Crippled by a painful and chronic illness that carried him off in the flower of his genius, Professor Finsen had to fight against many difficulties even to get his ordinary work done. When he was thirty-two he began to explore the effects of light on the human body, with results that have become more valuable with the lapse of time. He set out from the fact that there are three principal kinds of rays in ordinary sunlight—the red rays are heat-rays; the yellow rays are light-rays; the violet and ultra-violet rays have a chemical action which makes them a most important part of light from a medical point of view. It was these chemical rays that he studied deeply in his short and heroic life.

He found, in July, 1893, that the chemical rays of sunlight had a bad effect upon patients suffering from small-pox. It has long been a custom in China to put small-pox patients in a room so heavily draped with red hangings that all light is practically excluded. In Roumania it is an old popular practice to use red surroundings in the treatment of this illness, and in many parts of Europe in the Middle Ages red bedcovers were wrapped over the sufferers, and red globes were placed in their beds. All this was looked upon as a wild and fanciful superstition until Professor Finsen began to study the effect of daylight upon sufferers in the hospital at Copenhagen.

He found that in many cases he could prevent the disfiguring and dangerous eruption from breaking out on the patients by hanging two or three thick curtains of red flannel before all the windows. His object was only to admit the red heat-rays of light into the room, and entirely keep out the blue and violet and ultra-violet rays. In other words, he had to turn a room into a photographer's dark-room. The same kind of rays that spoilt the development of a photographic plate seemed also to have the power of inducing the small-pox eruption in the exposed skin of patients. In the end he found the most convenient way of preventing the trouble was to set aside certain rooms in isolation hospitals, and fill the windows of these rooms with dark red glass. The globes and lamp-glasses used in artificial lighting had also to be made of very dark red glass. The treatment, as Finsen pointed out in 1894,

NIELS FINSEN
Photograph by Riise, Copenhagen

did not cure small-pox, but it did much to prevent the eruption and the dangerous fever and the horrible scars which often are a consequence of an attack of small-pox.

Finsen then went on to study the physiological effect of the violet and ultra-violet rays, and came to the conclusion that they possessed a great stimulating force. Though prevented by illness and the pressure of other work from carrying his researches out completely, Professor Finsen managed at last to build a big electric-light bath, in which cold blue-violet rays were used to stimulate the blood-vessels and thereby promote a better nutrition of the skin and a greater functional activity.

In the meantime, he had made the great discovery on which his fame chiefly depends. There is a common and very disfiguring disease of the skin caused by the same microbe that sets up consumption when it attacks the lungs. For this disease, known as lupus vulgaris, no remedy was known. Having found by experiment that the tubercle microbe was killed by the action of concentrated chemical rays, it struck Finsen that the ultra-violet radiance might prove to have a curative effect on patients suffering from lupus. At first he had a great deal of trouble with the blood of his patients, for this protected both them and the deadly microbe from the action of the rays from the Finsen lamp. However, he got over the difficulty by putting a photographic plate behind his own ear, and bringing the radiance of the lamp to bear in front. He found that, if he kept his ear tightly pressed between two transparent plates, he drove all the blood out, and the chemical ray left a clear impression of its action upon the photographic plate. This was practically the crowning experiment of this sick and suffering hero of medical research. It enabled him to complete the main parts of his instrument for applying ultra-violet rays of light to the cure of lupus.

The affected part of the patient's skin has a small water-cell firmly pressed against it. This compressor serves a double purpose. The circulating water absorbs any heat-rays passing out of the lamp, and the pressure of the water-cell keeps the blood out of the tissues, so that the blood corpuscles are not there to obstruct the passage of the curative rays. The rays are usually produced by a powerful electric arc-lamp, and then focussed by means of a telescope tube in which are fitted quartz lenses, and the apparatus is cooled by water circulating through it. It is still doubtful which view held by Finsen is correct—that in which he attributes a stimulating curative effect on the human tissues to the chemical rays, or that in which he traces the effect to the destruction of the microbes by the ray.

However this may be, the Finsen light-cure has become an important branch of medicine, and in some malignant diseases the Röntgen rays are also employed. Finsen ranks as the founder of the science of Phototherapy, in which various kinds of rays are used for medicinal purposes. In true lupus the rays are so curative that the malady has been called "Finsen's Disease." Finsen died in 1904.

AUGUST FOREL
A Swiss Scientist Playing Many Parts

August Forel was born at Morges, Switzerland, on September 1, 1848, and educated at Zurich and Vienna. For many years he occupied the Chair of Morbid Psychology in the University of Zurich, and was medical superintendent of a great asylum. Recently he has retired from these official positions, but he works as hard as ever in other ways. Thus, while he published valuable observations upon insect life as early as 1874, as recently as 1906 he was making fresh observations upon the memory of time in bees.

Dr. Forel's work has ranged over so wide a field that at first sight its various parts seem to be disconnected, but they are one and all concerned with mind in its various aspects. To him, as to all great students—compare Darwin's work on the emotions—it is in a sense indifferent whether the mind he studies be that of a man or that of a bee; and he has always realised that the study of mental disease is, in large measure, not only useful for the mental physician, but also gives us the key to many facts of the normal mind.

It is only within the last few years that the work of this great student has become known at all to the English reader, even though, among his copious technical writings, he has found time to write much for the educated public. The English reader has, however, since 1907, been able to gain access to certain of Dr. Forel's works, as follows: "The Hygiene of Nerves and Mind in Health and Disease," in the Progressive Science Series; "The Senses of Insects," collated and translated by Mr. Macleod Yearsley, the distinguished aurist; and also a large and somewhat technical but valuable volume, "The Sexual Question"; and a small treatise, "Sexual Ethics," with an introduction by Dr. Saleeby. Dr. Forel has also written on hypnotism, and very largely upon the action of alcohol in relation to mental processes, and as a cause of racial degeneration by the process of what he calls "blastophthoria," or germ-spoiling. From these varied works we may obtain a fair idea of the philosophy and practical contributions of this indefatigable worker, who actually found time to write his largest book in German, and rewrite it himself in French.

Dr. Forel describes himself as a monist, and is perhaps not entirely without anti-theological bias, but his researches in comparative psychology have led him

definitely to repudiate the popular view, so easily stated, and shared by so many students of life at second-hand, that the living organism is a machine. He wholly condemns the error "which at all costs desires to see in every living organism a 'machine,' forgetting that a 'machine' which continually reconstructs itself is not a 'machine,' but something entirely different. It is, in fact, a problem to which we have not the key, and of which we can but study the form and function without comprehending the intimate connections of their causality, which are those of protoplasmic life." In short, Dr. Forel recognises purposeful adaptation as a primitive fact of life. In one of his larger works, also, the student will find a brilliant and suggestive discussion of heredity, on which subject Forel is a follower of the English writer Samuel Butler, and others who argue that Life remembers, and that heredity comprises, or indeed ultimately consists in, a process of the transmission of what is remembered, through the germ-plasm. To many readers this doctrine sounds mystical and non-scientific, but it is accepted by so very practical and concrete a thinker as Forel, and exactly consorts with the teaching of Bergson.

Forel's work on mental hygiene is masterly, and its translation into English, in a well-known series, was a public service. Every page testifies to the authority and sincerity of the author, one of those ardent investigators who are never satisfied until the facts at which they have arrived are shared and acted upon by other people.

In his contributions to the study of sex, Professor Forel shows himself to be an ardent Eugenist. Many foreign alienists, in recent years, have written large volumes on sex, and especially upon its pathology. Dr. Forel's stands alone in its consistent recognition of the essential sanctity of sex, and in his no less consistent application of the great criterion of true sexual morality—the effects of our acts upon ourselves, and upon the natural endowment which they transmit to posterity.

Lastly, Professor Forel is and always has been a most uncompromising opponent of alcohol, like the other great alienists of the time. But none of them are quite so ardent as Professor Forel. He has made numerous and important contributions to the literature of the subject, none of which, unfortunately, have yet been translated into English. It was owing to his persistence and influence that a few years ago the Swiss people abolished by a referendum the sale, import, export, or manufacture of absinthe.

SIR MICHAEL FOSTER

The Representative English Physiologist

Michael Foster was born on March 8, 1836, his father being a doctor in Huntingdon. The boy was prepared for the medical profession at University College, London, but soon found that the proper business of his life was the study, and perhaps specially the teaching, of physiology. In 1883 he became Professor of Physiology at Cambridge, and retained that post for twenty years. He was made a K.C.B. in 1899, and entered Parliament, as representative of the University of London, in 1900, but later lost his seat, oddly enough, in connection with the discussion on Tariff Reform.

Foster's "Textbook of Physiology" was first published in 1876, and was, for a quarter of a century, the standard treatise on the subject in the English language. He was a masterly writer; and the very model of what such an article should be is his famous contribution, "Physiology," to the "Encyclopœdia Britannica," first published in 1885, and containing in its fifteen pages the most admirable summary of and introduction to the great subject of vital functions that it is possible to imagine.

We are much indebted to Sir Michael Foster for his introduction of the term "metabolism," to signify the chemical processes of the organism; and of the further terms "anabolism" (or constructive metabolism, as he calls it in the article above referred to), to indicate the processes of chemical synthesis, seen chiefly in the green plant; and "katabolism," or destructive metabolism, to indicate the processes of chemical simplification, usually oxidations, whereby the animal organism especially obtains the kinetic energy which its life continually displays.

Sir Michael Foster died January 29, 1907.

SIGMUND FREUD

The Action of the Mind in Dreams

Sigmund Freud was born in 1856, at Freiberg, Moravia, and took his doctorate of medicine in the University of Vienna in 1882. Three years later he began to teach nervous pathology, and since 1902 has held the title of Extraordinary Professor on that subject in his *alma mater*. He edits various journals of psychiatry. Hitherto the importance and remarkable originality of

Freud's work have received little recognition except among experts.

It was in 1900 that Professor Freud published the first volume in which his own contributions to knowledge appear. This was his "Interpretation of Dreams," an English translation of which is shortly to be expected. The title of this remarkable book has a quaint and familiar sound, for men have undertaken the interpretation of dreams since the dawn of history, but Professor Freud's interpretation of dreams is scarcely of the same order as those to which we are accustomed. He recognises that the facts of consciousness, whether waking or dreaming, express and largely depend upon deeper facts of the subconsciousness. In the ordinary waking life he recognises a potent and unceasing factor of inhibition, which controls the suggestions made by the subconscious mind, and wills the course of the "stream of consciousness." Many deep and potent emotions may be present, but they and their consequences are suppressed. Professor Freud thus speaks of "strangulated emotions." But in sleep the inhibition exercised during the waking life is removed, and the emotions, suppressed during the day, can assert themselves.

Professor Freud thus finds a psychological interpretation of dreams. The physiological interpretation, as we may call it, held the ground until his time. Thus, lobster and cheese, taken at supper, disturbed the stomach and the "solar plexus" of nervous matter which lies behind the stomach, and dreams resulted. There is a part-truth, of little moment, in this explanation, but it does not tell us at all why the dreamer dreams the dream he does, and not another. Here, indeed, until Freud's time, was a realm of natural phenomena where men of science were practically content to assume the existence of a causeless chaos. But it is not so, and Freud has gone very far to show how the dreams we dream can be interpreted in general and in detail. More than this, he has been repeatedly able to relieve his mental patients by the analysis of their dreams, especially with the aid of the facts of the subconscious mind which he has been able to obtain from them while they have been in the hypnotic state.

For Freud's analysis of dreams is really only a part of his general theory of the mind and its behaviour. Quite apart from dreams, many of us have in our minds subconsciously preserved emotional effects which we are not aware of, and yet which injure our mental health and happiness. They may be called psychical lesions or wounds; and the reader will observe how far we are wandering from the idea that insanity is "a disease of the brain." With patients in whom such strangulated emotions are suspected, Dr. Freud and his followers—who are now arising in large numbers in all the great centres of medicine—endeavour by hypnotic suggestion to get back the memory of the original situation which produced the trouble in the first place, and which the conscious mind of the patient has often forgotten. Then by appropriate suggestions the pyschical wound can be treated and healed. In hosts of cases where all other means of treatment have failed this succeeds.

If we briefly mention Dr. Freud's "Three Essays on Sex," and his chief work, "Psycho-Analysis," we may proceed to state, in general, the new conceptions of the mind, in health and in disease, which his method of psycho-analysis has established. His special views on sex need only briefly be mentioned, though he has elaborated them quite lately, especially in relation to the so-called "sexual life of childhood." He seems to be not entirely immune towards the extraordinary obsession of sex which has afflicted Continental writers during the last decade, causing them to find sex in any and every manifestation of conduct, in health or disease, from religious devotion to biting one's nails. Nevertheless, there can be no question that Freud's remarkable genius for psychical interpretation has led him repeatedly to the correct explanation, in the suppression of the emotions of sex, for many of the phenomena of our lives besides those which are sometimes summed up in one individual as "celibate insanity."

At the time, only a few years ago, when the new ideas of Freud came upon the scene, medical science was entirely dominated by the second of the three successive views of insanity. The first, or demonological view, the view of insanity as possession by demons, had given place to the physiological view of insanity which is now the established view of orthodox medicine, and is to be found in its highest form in the most recent writings of such an authority as Sir Thomas Clouston. On this view, all insane manifestations have a physiological or anatomical basis, if only our chemical and microscopic methods were clever enough to detect it. Insanity is thus a symptom of physical disease of the physical collocation of molecules which we call the brain. It will be readily seen that this view is simply

the medical counterpart of the materialism which had such a vogue in the latter part of the nineteenth century. The notion of the mind as an entity has disappeared. The mind is merely a consequence of the brain—healthy mind of healthy brain, diseased mind of diseased brain. We may not know the details, but that is the essence of this physiological view.

The objection to such a view, in which a very large amount of truth is apparent, when we study the brains of the syphilitic or alcoholic, is that there are hosts of facts which it does not explain or even bear upon at all. Half a century and less ago it was supposed that the whole nature and causes of insanity, and all its symptoms, would soon be revealed. Cerebral localisation was expected to find "centres" for all the facts of psychical life, and then we should find the centres diseased when the corresponding psychical facts were distorted. But everyone knows that these expectations have been disappointed. Freud and his followers teach us that we require to make a fresh start with a purely psychological conception of insanity, leaving out of account the brain and its appendages. We must now return afresh to the phenomena of insanity, and see whether we can by any means interpret them in terms of the mind—not of "brain-cells" and "neurones," and so forth. This is what Freud has done for us; and the reader who desires a trustworthy introduction to his epoch-making work will find it in the volume "The Psychology of Insanity," by Dr. Bernard Hart.

Freud has shown how psychical dissociation is the great feature of insanity, and how this dissociation depends upon intrapsychical conflict between different instincts, and upon the forcible repression of one or another aspect of the personality, due to the circumstances of the individual's life. He shows how all the processes of the insane mind, without exception, are variants or exaggerations of the processes of the sane mind; he demonstrates that the irrationality of the lunatic is not due to the supposed "loss of his reason," but to the influence of repressed psychical facts of which we are unaware, but from which he is reasoning soundly. He shows how much less rational than we suppose we all are, and gives his students a new understanding of, a new sympathy with, and power of therapeutic relief for the lunatic.

Above all, Freud and his followers are teaching how, by a wiser education, and by a deeper understanding of the mind and its developments, we may learn to obviate that dissociation of the personality which is the essential fact of insanity.

GALEN

A Physiologist at the Dawn of Christianity

Galen, or Claudius Galenus, in the Latin form of his name, was born at Pergamus, in Mysia, of Greek parents, about 130 A.D. His father, a man of rare qualities, chose for his boy the profession of medicine, which he began to study when he was about sixteen. He learnt in Smyrna, Corinth, and Alexandria, and in 164 at length he reached Rome, where he spent a great part of the rest of his life. He was personal physician

GALEN

to the noble Emperor Marcus Aurelius, and afterwards to his worthless son Commodus.

This assiduous and ardent student became, in due course, first a pioneer in many points of medical theory and practice, and, second, the encyclopædic mind of his age in medical matters. All that was taught, written, and supposed, from Hippocrates onwards, he endeavoured to reduce to order. He was an untiring writer; indeed, the modern student marvels again and again at the sheer bulk of the written matter which Galen and so many of the ancients left behind them. He wrote numerous original treatises, and many commentaries upon the

writings of his great predecessor Hippocrates. His writings were by no means all medical; the practice of medicine had not, in those days, undergone its modern and most unnatural divorce from other studies which are involved in the health and sickness of the mind and body of man. As a boy, Galen had been nourished upon the stern fare of the Stoic philosophy. He was greatly interested in logic, and wrote a special treatise on the fallacies of language.

Galen was not, however, a writer merely. In his day there was no science upon which medical practice could securely be based. He had great clinical success, and an unrivalled contemporary reputation, being called the "Wonder Worker," but his results must largely have been due to his prestige, and to what we nowadays call common sense. None knew better than he—none knew so well—that the very foundations of his art did not exist, and he set to work to make them. This is why we must greatly honour him. To be the first physician of one's age, the attendant of emperors, the pocketer of huge fees, would be enough for many men, but it was far from being enough for Galen.

Human anatomy scarcely existed in those days, but Galen devoted much time to the dissection of the bodies of animals, notably monkeys. He studied many of the higher vertebrates, including one elephant. Above all, he is to be ranked as an experimental physiologist. In his time the arteries—or air-carriers, to translate the Greek—were supposed to carry air from the heart to the brain (where it was supposed to be cooled) and other parts of the body. Galen opened an artery in a living animal, and found that it contained not air but blood, though we call these blood-vessels arteries, or "air-carriers," to this day. In the corpse, an artery is found to be empty, the blood having accumulated in the venous part of the circulation as the heart failed at death; hence the error of many centuries.

Galen fully realised the wonder and significance of his physiological researches. He tells us that his treatise on the uses of the parts of the human body is really a hymn to the Deity. "I hold," he says, "that true piety is shown not in the sacrifice of hecatombs of bulls, or in raising clouds of fragrant incense, but in studying myself to know, and in making known to others, the wisdom, the power, and the goodness of God."

The heart, said his contemporaries, is the seat of the soul—for a man lays his hand on his heart when he is referring to himself, Hence, also, as the propinquity of the windpipe to the heart shows, the voice comes from the heart! Galen, on the contrary, correctly stated the functions of the chest-wall, the larynx, and the nerves of the chest-wall, in the production of the voice—a marvellous feat indeed. And he complains—"When I tell them this, and add that all voluntary movement is produced by muscles controlled by nerves coming from the brain, they call me paradoxologos—a teller of wonderful tales—and have no argument beyond the assertion that the windpipe is near the heart."

Galen's observation upon the so-called "arteries" was extremely valuable, and led him, for instance, to initiate the clinical study of disease by feeling the pulse. But his researches upon the functions of the nervous system were more valuable still. He discovered the relation between one side of the brain and the opposite side of the body; he discovered what the function of the brain is, indeed; and he knew that paralysis of the lower part of the body is produced by section or damage of the spinal cord. He is, indeed, the founder of nervous physiology. After all this, it seems almost a trifle that he should have been the first to understand the function of the kidneys.

But Galen was a physician, too. He not only studied function and methods of diagnosis, but also devoted much time to therapeutics by means of drugs.

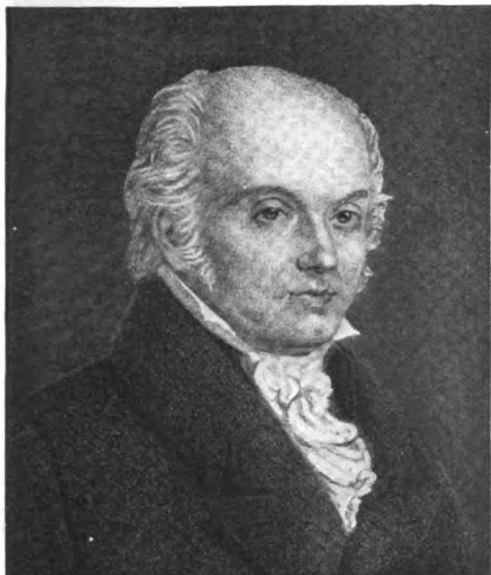
At this day we speak of "galena," and describe certain pharmaceutical preparations as "galenical." The methods of scientific inquiry, which we call modern, and which some suppose Bacon to have first devised, were practised consistently by this amazing genius—a kind of aftermath of the great age of the Greek mind—throughout the whole range of his inquiries. His successors had only so to proceed, and long before the year 1000 men would have known far more of health and disease than was known in 1850. But the "thousand years of darkness," of which we are the victims today, were to follow.

Galen knew nothing of that. He went on with his work. Apparently he retired from practice, and he is said to have returned to his native town. It is uncertain whether he lived to the age of seventy or eighty, and opinion is divided as to whether or not he died in Sicily, but it is certain that he left an undying name.

FRANZ JOSEPH GALL

The Founder of Phrenology

Franz Joseph Gall was born near Pforzheim, in Baden, on March 9, 1758, and studied medicine in Strasburg and Vienna. In 1785 he qualified, and began to practise. He was already inclined to believe in the correspondence between certain external traits of the face and certain characteristics of the mind. This was what today, following Lavater, we should call physiognomy. But thence Gall proceeded to argue that even the form and size of the skull (as indicating the form and size of the brain within) might correspond to psychical characteristics. Hence phrenology — the science of the *phren*, or mind.

Galen had shown, sixteen hundred years

FRANZ GALL

before Gall, that the brain is concerned with mental functions, but the astounding fact, one of the most remarkable in history, is that, throughout all that long period, practically nothing had been added to what Galen found. Physiological inquiry had sunk into a deep and dreamless sleep. Science had all but stopped, thanks to its natural enemy, dogma.

Beyond doubt, Gall had a great idea in this phrenology of his. There was in it nothing irrational or improbable; and if he had called it, as we now should, a "working hypothesis," and had proceeded to base upon it those lines of research which it suggested, he would have gone far indeed. However, he began to lecture on the subject as early as 1796, and soon found that his views were not to the established taste. In fact, his lectures were suppressed, on the ground that they were opposed to the truths of religion. Meanwhile, Gall had obtained a capable disciple in the person of Johann Gaspar Spurzheim, and the two began to lecture in several countries of Europe, reaching Paris in 1807, and beginning to practise there. Six years later, Gall and Spurzheim quarrelled and parted, but meanwhile they had composed various large works, part of which were formally presented to the scientific world in Paris, and by it they were received unfavourably.

This was a very different matter from the original condemnation of phrenology — without which, so great was its effect as an advertisement, we should probably never have heard of phrenology at all. The French men of science judged Gall's work on its merits as a contribution to natural truth, and they found it wanting. We now know, beyond all dispute, that they were right. Gall's basal idea was reasonable enough, but he had no real knowledge, and extremely inadequate notions as to the fashion in which knowledge of such matters can be obtained. The functions of the brain have since been localised, and we know that *not one* of the psychical characteristics which Gall professed to localise is represented at any point or area upon the brain. Muscle-groups, and sensations, are there represented, but there is no brain-centre for love or hate, wisdom or folly, courage or cowardice. Gall taught and practised in Paris until his death, on August 22, 1828.

SIR FRANCIS GALTON

The Founder of the Science of Eugenics

Francis Galton was born, near Birmingham, on February 16, 1822, of distinguished Quaker ancestry. One of his grandfathers was Erasmus Darwin. His other grandfather, Samuel John Galton, he describes as a "scientific and statistical man of business." His father had a passion for measuring things, and this "decidedly statistical bent," which was so very conspicuous and useful in Galton himself, showed itself, as he tells us, in a useless and almost insane form in one of his aunts. Through one grandmother, Galton was descended from the seventeenth century Quaker apologist Robert Barclay, who taught and expanded the essential doctrine of the Society of Friends, that "all true knowledge comes from Divine revelation to the heart of the individual."

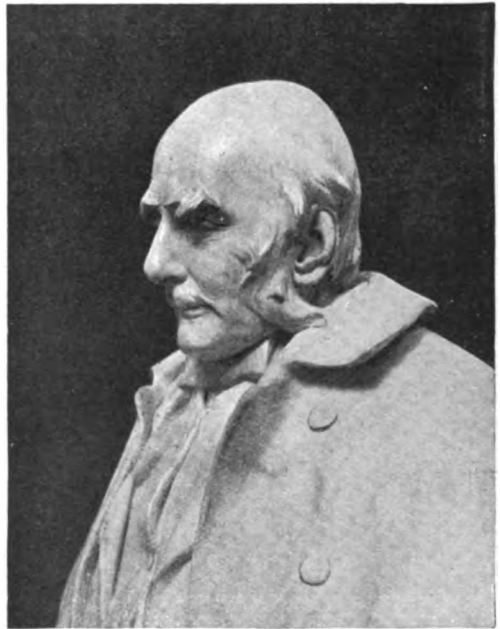
Galton was born the youngest of a family

of seven, and owed much to his invalid sister, Adèle, who had spinal curvature, and devoted herself to his education. He says, "I am enormously indebted to the influence of her pious, serene, and resolute disposition."

Then the little boy went to school at Boulogne, to learn French. He learnt nothing, and was miserable. At King Edward's School, in Birmingham, under a famous classical teacher, he also learnt nothing, but at the age of sixteen he left school, and started to study medicine, which fascinated and awed him. He learnt much at the Birmingham General Hospital, and his alert, tireless, statistical mind began to work rapidly. He began to take small doses of every drug in the pharmacopœia, beginning with A, in order to study their effects, but stopped after a painful experience with two drops of croton oil. He soon began "vaguely to perceive that doctors had the fault, equally with parsons, of being much too positive." He saw and deplored the inadequacy of medical statistics, for which he was to do much in after years. Then he studied medicine further in Cambridge, and at St. George's Hospital, but in 1840 he was taken with a passion for travel, and off he went to the East.

Francis Galton was many things, and among them he was a traveller by nature. He could not help himself; and the possession of ample means, which prevented him from ever qualifying in medicine and settling down to practise, enabled him to travel largely. He was the first, or among the first, to explore the White Nile and Damaraland. For this he received the gold medal of the Royal Geographical Society. His "Art of Travel," published in 1855, became extremely popular, and went into many editions. Those of today who only knew Sir Francis Galton as an asthmatic old gentleman are apt to forget he had been one of the greatest explorers of his day.

Perhaps the greatest lesson he learnt was his tolerance for, and sympathy with, all sorts and conditions of men, though doubtless his own nature and the early influence of his sister were largely accountable also. No words can avail to contrast the gentle, wide, calm tolerance of this founder of eugenics with the crude nationalism, the race prejudice, and the class prejudice which abound in the statements of some of his contemporary interpreters. Galton had in him no vestige of any of these evil things, and the student of his life may begin to understand why. Thus, he tells us how, on a visit to Egypt, "the Sheikh was sent for, and I shall never forget his entrance. The cabin reeked with the smells of a recent carouse, when the door opened, and there stood the tall Sheikh, marked with sand on his forehead that indicated recent prostration in prayer. The pure moonlight flooded the cabin, and the clear, cool, desert air poured in. I felt swinish in the presence of his Moslem purity and imposing mien."

The foregoing is quoted from the "Memoirs of My Life," which Galton published in 1908, and which must always rank as a model of autobiography. The ardour, the candour, the humour, the delight in life, the humility, the humanity, the richness of mind, which were the natural

SIR FRANCIS GALTON

attributes of this illustrious man, are stamped upon successive pages in a fashion which reveals the man himself to the life. This was the last of his many books; for though he once conditionally promised to undertake a volume upon eugenics, he fought shy of the task later.

In 1853 Galton married a member of the brilliant Butler family, but this founder of eugenics left no children for posterity. His marriage introduced him to social life, which he enjoyed, though if ever the saying was true, "A chiel amang ye taking notes," it was true where he was. He used to count people's fidgets to measure their interest, using his own pulse, furtively felt, as a watch.

Soon he became connected with the British Association, which he served faithfully in many capacities, though he twice refused its presidency. The special branch of science to which he now turned his attention was meteorology, upon which he left his mark no less definitely than upon geography. His passion for recording and comparing observations led him to undertake the huge task of charting the weather on a really substantial scale; and in the course of these studies he discovered, named, and defined the characters of the meteorogical condition which he called the anticyclone, and for which, owing to its pleasing character, the name of halcyon has recently been proposed. At Kew Observatory there was no stopping this remarkable man. He standardised the sextant. He contrived his apparatus for testing clinical thermometers—a most important matter—and tens of thousands of such thermometers are now annually tested by this means. Then he suggested and established the rating of watches and chronometers.

Sooner or later such a man was plainly destined to start the measurement of living beings. As early as 1865 he had shown that talent may be inherited, and was devising schemes for measuring it and its inheritance. He measured boys at Marlborough, thanks to the then head-master, afterwards known as Dean Farrar. In 1882 he suggested the establishment of anthropometric laboratories, and he established one at his own expense at the famous Health Exhibition of 1884. In order to study the limits of hearing, he invented "Galton's whistle," whereby the pitch of a note can be raised until it can be heard no more. This is in daily use by aurists. Here, in passing, he came across finger-prints, because he wanted a novelty for a lecture requested by the Royal Institution. He put his usual thoroughness into this subject; and now, all the world over, criminals are identified, thanks to his work. Never yet has his method failed, and all others are superseded. Composite portraits, a fascinating subject, came in with the study of criminals, and stereoscopic maps "happened" in his mind by similar mental processes.

A small fraction of the foregoing would suffice to make a great life-work for any man, but we have scarcely yet alluded to the most important matter of all. The following names of books indicate it: "Hereditary Genius," 1869; "English Men of Science," 1874; "Human Faculty," 1883; "Natural Inheritance," 1889. The tragedy is that, before this series of books was begun, Mendel's work had been already published, but Galton knew no more of its existence than did his cousin, Charles Darwin.

In 1883, in "Human Faculty," Galton introduced the word "eugenics"; and to this subject, after many years during which, for lack of encouragement, he left it alone, he devoted the last decade of his life. He had already experimentally disproved Darwin's theory of pangenesis; he had seen the fact of heredity in man; and finally, aided by an invitation from the newly formed Sociological Society in 1904, he initiated the present public interest in and importance of eugenics.

The essential ideas were as old as 1865 in his mind, but now the time had come. He lived to see eugenic societies founded, and to address one of them, to contribute to a eugenics review, and to found a eugenics laboratory. Those who were honoured by his friendship in his later years, to whom he confided his dreams, and whom he humbly consulted in his plans for their realisation, will have an unfailing recollection of moral, intellectual, and physical grandeur such as it would need the pen of the Browning of the "Grammarian's Funeral" to express.

Francis Galton died on January 18, 1911, and by his will founded and endowed the Francis Galton Professorship of National Eugenics in the University of London, now held by his friend Professor Karl Pearson.

PATRICK GEDDES
Educator and Sociologist

Patrick Geddes was born on October 2, 1854, at Perth, and had a varied education, which comprised Perth Academy, University College, London, the Sorbonne, and the University of Edinburgh. No less varied, and characteristic of the man, were his earlier teaching experiences, which were concerned with botany, natural history in general, and physiology, in London, Aberdeen, and Edinburgh. In between these pieces of work, Geddes travelled widely, and thus developed his natural interest in geography, city-planning, and "regional survey." He is now, and has been for some years, Professor of Botany in the University of St. Andrews, but the duties of this Chair allow him ample time for his ceaseless activities as a teacher and student of life in the widest possible sense of the word. His work is not easy to summarise or define, on account of the very variety and originality which make it so interesting, but it all depends upon the

application of biological principles and ideas to the enhancement and exaltation of human life.

His older and more conventional work is best represented by his articles on reproduction, variation, morphology, etc., in the "Encyclopædia Britannica," and especially by the famous volume "The Evolution of Sex," which he published in 1889, in collaboration with Professor J. A. Thomson, of Aberdeen. This book was presented in a new edition in 1900; and the suggestion may here be made that yet another edition is needed in the light of the rediscovery of Mendelism, made in that year.

In the admirable preface to the edition of 1900 the authors wrote these prophetic words: "Our hope is that the growing strength of the still young school of experimental evolutionists may before many years yield results which will involve not merely a revision but a recasting of our book." Those results have now been obtained, in the manner predicted; and it would be a public service for these distinguished authors now to recast the famous volume which has sown the seeds of thought in the minds of so many students throughout the world for nearly a quarter of a century.

The principal thesis of this book, traceable, no doubt, to Professor Geddes himself, is that the essential difference between the sexes consists in the fact that the ratio of anabolism to katabolism is higher in the female than in the male. To quote exactly, "In one sex, the female, the balance of debtor and creditor is the more favourable one; the anabolic processes tend to preponderate, and this profit may be at first devoted to growths, but later towards offspring, of which she hence can afford to bear the larger share. . . . This for us is the fundamental, the physiological, the constitutional difference between the sexes. . . . In higher animals, it is true that the contrast shows itself rather in many little ways than in any one striking difference of habit, but even in the human species the difference is recognised. Everyone will admit that strenuous spasmodic bursts of activity characterise men, especially in youth, and among the less civilised races; while patient continuance, with less violent expenditure of energy, is as generally associated with the work of women."

Latterly Professor Geddes's writing has been fragmentary, though valuable. His mind is too alert and impatient, his practical activities too numerous, for him to find time for the production of a treatise. The most important of his recent contributions to thought will be found in the first volume (1904) of "Sociological Papers," published by the Sociological Society, of which P ofessor Geddes was one of the founders and moving spirits. In the summer of 1904 Galton introduced eugenics to the thinking world from the platform of that society; and Professor Geddes gave us the correlative need in his great conception of what he calls "civics." For him civics is "applied sociology." We must take our science of society, itself based upon the biology and psychology of the individual, and then we must apply it to the making and maintaining of great cities and states, great in every true and profound sense of the word. That is civics, a new word for an idea which is as old, of course, as Aristotle, and to which the Greek thinker gave the name of "politics," now "soiled with all ignoble use."

Let us now see how Professor Geddes has sought and seeks to translate this civics of his, from the splendid pages above cited, to the life of our time. To begin with the oldest instance, he has always considered that the academic life of the students, even at universities of the modern type, should have a social and moral basis, conforming more or less to what Oxford and Cambridge are supposed to be and in part may once have been. Thus he set himself to establish a University Hall in Edinburgh, with splendid success. There he now has a summer meeting every year, and his famous Outlook Tower, which he describes as "partly a regional and geographical type museum, partly also for undertakings of geotechnic and social purpose—*e.g.*, city improvement (Old Edinburgh, etc), parks, gardens, etc." Everyone north of the Tweed knows what this work of Geddes has done for Edinburgh.

Then he determined to do the same for London. Thanks to him, University Hall, Chelsea, now exists; Crosby Hall has been re-erected there, and a definite beginning is assured for what as yet has never existed in the largest city in the world, a social-academic life of students, the young "intellectuals" of both sexes, who are to be the salt and salvation of the next generation. The University of London, till lately a mere examining body, will thus yet become worthy of the vastness of the city of its habitation.

In Edinburgh in 1912 Professor Geddes expressed his educational fervour and ideas in a new and highly successful form. This

was his "Masque of Learning," divided into two parts, Ancient Learning and Mediæval and Modern Learning. This masque was practically a pictorial and dramatic representation of the history of science, from the very discovery of fire until our own times. In the "Athens of the North" this masque had the most remarkable success. Thousands of school children learnt from it, and its educational value was so great that in March, 1913, it was repeated at the Imperial Institute in London.

SIR WILLIAM GOWERS

The Greatest Living Neurologist

Sir William Gowers was born in London on March 20, 1845, and was educated at Oxford and at University College, London, with which he has been associated all his life. He early devoted himself to the study of the nervous system, and in due course attained the rank of the greatest living neurologist, as he now admittedly is. He was knighted in 1897, and is a Fellow of many learned societies at home and abroad.

In 1879 he published his paper on the very remarkable malady which he called "pseudo-hypertrophic muscular paralysis," and which is now generally known as "Gowers' disease." This is a rare but extremely remarkable affection of certain parts of the nervous system, and, like many other diseases, is confined, or almost wholly confined, to the male sex. In consequence of the nervous degeneracy, the muscles, especially of the calves and shoulders, become paralysed, but they enlarge in bulk, owing to fibrous tissue, which is useless. The mother is thus usually proud of her boy's big muscles, but their size is a "pseudo-hypertrophy." Within the last few years Gowers' disease has received special genetic study by those who are unravelling the laws of sex-limited inheritance, and we now know that this disease, like colour-blindness and many others, obeys the Mendelian law with a sex-limit.

Sir William Gowers has also made valuable contributions to the study of epilepsy, and of the various appalling forms of damage which are done by the poison of syphilis in the nervous system. He has been prevented by ill-health from doing very much original work in recent years.

ERNST HAECKEL

The German Populariser of Darwin

Ernst Heinrich Haeckel was born at Potsdam on February 16, 1834, and was educated at Berlin and Würzburg under such great men as Johann Müller and Rudolf Virchow. At the early age of twenty-eight he was made a Professor of Zoology at Jena, and he held that Chair until his retirement, in 1909.

When the young Haeckel was appointed to his Chair, the "Origin of Species" had just been published. The ardent young German naturalist became a disciple of Darwin, and he, more than all others put together, has been responsible for the spread of the idea of organic evolution in Germany, playing, with no less vigour of belief and phrase, the part which Huxley played in England. Never did gentle man have more hot-blooded disciples.

Haeckel has always been a copious writer, and his writings on organic evolution and the ultimate problems of philosophy are very extensive. His "General Morphology" was published in 1866, and the "History of Creation" two years later. A recent and authoritative critic, Dr. Merz, says of these works that they "represent the first brilliant attempt to fill up conjecturally the broken lines of development and descent as the Darwinian conception of living Nature postulates them. As a first and daring approximation, they deserve to have assigned to them a prominent place in the history of the scientific thought of our age." Darwin's own verdict on these early works runs as follows: "Professor Haeckel has brought his great knowledge and abilities to bear on what he calls phylogeny, or the lines of descent of all organic beings. In drawing up the several series he trusts chiefly to embryological characters, but receives aid from homologous and rudimentary organs, as well as from the successive periods at which the various forms of life are believed to have first appeared in our geological formations. He has thus boldly made a great beginning, and shows us how classification will in the future be treated." Huxley, also, wrote as follows: "Whatever hesitation may not unfrequently be felt by less daring minds in following Haeckel in many of his speculations, his attempt to systematise the doctrine of evolution, and to exhibit its influence as the central thought of modern biology, cannot fail to have a far-reaching influence on the progress of science."

Haeckel's central idea is what he calls the "law of biogenesis." His readers may suppose it to be his, but it is much older. He, however, has used it for all that it is worth—and, as we now know, a great deal more. It asserted that the history of each

individual is a recapitulation of the history of the race, and thus Haeckel has constructed, especially from the evidence of individual development, a genealogical tree-table of all living organisms, showing their descent as thus inferred.

Our quotations from Darwin and Huxley suffice to suggest that Professor Haeckel is a bold writer. In fact, he is the advocate rather than the seeker for truth. His mind is filled with the splendour of the theory of organic evolution, and with the most unmitigated detestation of anyone who thinks otherwise, especially in the name of religion. He feels that he *must* prove the case in which he so earnestly believes as containing everything necessary for human salvation as he understands it; and the ingenuous reader is apt to pass from the realm of fact to that of speculation, in this author's company, without any consciousness of the hazard incurred.

No doubt the doctrine of organic evolution needed all possible help. It was in a tiny minority, and all established things were against it. Haeckel was a magnificently endowed champion, and his services can never be forgotten. He saw the living world, animal and vegetable, as a whole, and tried to bring the history of plants into line and order with that of animals. Every kind of argument was necessary for his purpose, and thus he never rejected the views of Lamarck in order to advocate those especially associated with the name of Darwin. He has thus avoided the errors of the neo-Darwinians, and his writings have gained in breadth proportionately.

As Dr. Merz says, "It is his undoubted merit to have attempted for the first time to carry out this general scheme on a large scale, and by means of detailed pedigrees, beginning with the undefined organisms in which as yet the peculiar characters of animal—and plant—life do not appear to be differentiated, and ascending in two great trunks into the vegetable and animal kingdom, and thence through many ramifications into the several classes, families, genera, species, and varieties of living things, to construct the supposed real, natural system for which systematists had been unconsciously searching since the age of Ray and Linnæus."

An author so enthusiastic, so bold, so confident of his views even where no evidence existed, could not fail to be invaluable as a controversialist. Throughout the world for many years he has been the acknowledged champion not merely of organic evolution, but of a thoroughgoing naturalism which is typically and utterly materialistic in every particular. Darwin did not publish his views upon man until 1871, and three years later Haeckel was ready with his large work "Anthropogenie," of which a revised edition has lately been translated into English. More important still, from its influence upon the popular thought of our time, has been the "Welträthsel," or "Riddle of the Universe," which was published in 1899, and of which, in the original and in twenty-four translations, several hundreds of thousands of copies have been sold.

In this extremely able and engrossing book the dogmatism and violence of the author's mind have reached their height. The modest level of Huxley's "agnosticism" finds no counterpart here. This author does not assert himself to be one who does not know about the ultimate problems. On the contrary, he *does* know, and asserts the fact accordingly. Biology is left behind altogether—not merely the special departments of it which the author has studied at first-hand, but biology as a whole. The author passes into the realms of philosophy, and gives his conclusions there.

This is, of course, a perfectly legitimate process. Philosophy must be in accord with the facts of science; and the man of science ought not to be content until he has tried to make his facts fit into or serve towards the construction of a system of philosophy. But the methods which serve when a first-hand student is stating the facts of the embryology of some animal for the reader who has not studied them for himself are not necessarily adequate when the author employs them for the solution of the problems of the ages.

Professor Haeckel, as a philosopher, is not to be taken seriously, though he must have captured the minds of a vast host of young people throughout the world. Just as, in the dawn of Darwinian speculation, the young Haeckel was sure and went gaily ahead, where Darwin and Huxley knew that they knew nothing, and where later research has not justified him, so in his old age this remarkable man is sure of his answers to all the ultimate problems of the nature of life and matter, the origin and destiny of man and the universe. If his strenuous life is a little prolonged, his eightieth birthday will find him the recipient of honour from all throughout the world who, whatever their own opinions, value ability, sincerity, and devotion.

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EXPLORERS

WILLIAM DAMPIER

The Most Romantic Villian who Ever Sailed the Seas

WILLIAM DAMPIER was born near Yeovil, and was baptised on June 8, 1652. Circumnavigator, pirate, privateer, hydrographer, diarist, author, Dampier stands out one of the fascinating yet unlovely figures of the spacious bad old days. He lived a hundred men's lives, faced death in as many forms, yet died in his bed, and remains as well known to our generation as if he had lived but a generation ago. His life is full of the wildest romance.

His father, a small farmer, died when the boy was but ten, and his mother, who had given him as sound an education as was available at the Yeovil Grammar School, succumbed six years later, so that Dampier's world-wide wanderings began when he was sixteen. After experiences of the sea which took him westward to Newfoundland and eastward to the Dutch East Indies, he joined the Navy, and fought as an able seaman in the Dutch War of 1673, returning invalided. Then he went out to Jamaica, whence he drifted on to Campeachy, famous then, as now, for its woods.

In his rough, wild way Dampier was always a student, and began a diary which, with certain omissions, he continued more or less to the end of his days. He had an inherent faculty for the calling of the pilot and the charting of unknown seaways ; he had also the daring instinct of the man who today finds solace for his turbulent spirit in the semi-savagery of the mining settlement. He threw in his lot with the log-cutters of Campeachy; then, after a couple of years of hard work, he returned to England with his earnings, married, but was soon off again, this time to join a gang of pirates, whom he euphemistically described as privateers. But, as they themselves announced to their victims, they carried their commissions on the muzzles of their guns. With his lawless comrades he marched across the Isthmus of Darien, where today American engineers are putting the finishing touches to the Panama Canal. They sacked cities, were repelled with loss from others, fell out, as is the way of rogues, and divided their forces. Dampier and four others, joining a French piratical craft, exchanged into one commanded by an Englishman; then, finding their own ship too small, helped themselves to a larger—a Danish ship which mounted thirty-six guns. In this they joined other freebooting vessels, and harried the coasts of Chili, Peru, and Mexico, sailing thence across the Pacific and touching at the Philippines, China, and Australia. On the way they ran short of provisions, and fetched land with only a day's supply left, and when a majority had planned to eat, first their captain, who was a plump man, and such others as might be necessary to enable them to complete the voyage. Dampier was lean, but marked as edible.

They left their captain and a number of the crew behind before reaching Australia, and afterwards Dampier with three companions were put ashore on Nicobar Island, whence they made their way in a native canoe, amid terrible perils, to Acheen. Dampier's skill as a navigator brought them through, but the terrors of the voyage, the storms they encountered, and the privations they endured seem to have shaken even his iron nerve, and to have caused him to reflect on his evil past.

But it was the same impenitent Dampier who reached England to publish his almost incomparable " Voyage Round the World." Mainly on the strength of this, which had a remarkable sale for the time, and a later

volume, "A Discourse of Winds," which remains a classic even now, he was appointed to the command of a ship sent out by the Government to explore the great Southern Ocean. Dampier sailed in January, 1699, and explored the north-west coast of Australia, and the coasts of New Guinea and New Britain, giving his name to the Dampier Archipelago and Strait. On the way home his ship, which had become utterly unseaworthy, had to be beached at Ascension Island, which was then uninhabited. Happily the mariners found a spring of fresh water and abundance of goats and turtles, and lived in relative

WILLIAM DAMPIER

comfort for some four months, when a passing ship took them off.

Dampier's two visits to Australia were important in the history of exploration. His first sight of the island-continent, described in his volume, stimulated public curiosity and interest. It was a truly British act to send a ship so far on such an errand. The Dutch had established contacts with various points of the continent; but nothing serious was done beyond the bestowal of various names associating the land with the story of Dutch daring in their great days of sea-power.

Dampier's second visit was the first successful attempt to gain an accurate notion of the features of the land that lay out in the mysterious Southern Ocean. From Shark's Bay he explored the coast-line for nine hundred miles, and made good and useful charts. But the curious thing is that the knowledge he gained served but to retard the colonisation of the island-continent. He happened to touch Australia along a line where her most repulsive features are exhibited ; he saw nothing but grim savages and fabulous beasts, no sign of fertile land, only barren rocks and worthless waste expanses. And it fell out that while interest in the mystery never diminished, desire to possess was not kindled until Captain Cook descended upon the smiling east coast of the island-continent, and saw that the land was beautiful and of rich promise.

In connection with this voyage Dampier was court-martialled for gross ill-treatment of his lieutenant, punished, and declared unfit to command a ship. Still, he was sent out again in command of two privateers to the South Seas, and met with nothing but failure. He was utterly unfitted to command. The master of his second ship was Alexander Selkirk, and him Dampier marooned on the island of Juan Fernandez. Selkirk lived there alone for four years and four months. At the end of that time there arrived a buccaneer in the person of Thomas Dover, M.D., inventor of the "Dover's powder" still sold by the chemists. On board, as pilot, was the erstwhile Captain Dampier. He had remembered Selkirk, and they took him off. Dampier went round the world again with Dr. Dover, and on the way they sacked the city of Guayaquil, in Peru, stored their plunder in the church, and slept on it, to be "annoyed" by the smell of the recently buried bodies of persons who had died of plague. Within eight-and-forty hours, nine score of the men were struck down with the sickness, yet Dover saved all but eight of them.

But the main interest of this voyage for us today is the redemption of Alexander Selkirk. An account of the incident was written by Woodes-Rogers, Dover's chief commander. Defoe read the story, and out of it created the imperishable "Robinson Crusoe." So indirectly we owe that matchless treasure to Dampier—first, for marooning Selkirk ; secondly, for bringing him off. Dover and party returned to England in 1711, bringing booty valued at £200,000. But Dampier did not live to receive his share, the money not being apportioned until 1719. He died in March 1715, and his will is still preserved. The amount of his estate is not mentioned, but the will disproves the statement that he died in poverty. It was

a strange and lurid career, abounding in evil, yet productive of benefit to his generation. He was a born navigator, a keen observer, a trustworthy hydrographer, and his writings are a precious index to his times.

JOHN DAVIS

The Man who Led the Way to the North-West Passage

John Davis, who was born at Sandridge, near Dartmouth, in or about 1550, was one of the fathers of Arctic navigation. Like Frobisher, he dreamed of a North-West Passage, and succeeded in enlisting for his project such substantial interest that in 1585 he set out, after long experience of the sea, to make his way where so many other men were valiantly but ineffectually to follow. To him we owe the rediscovery of Greenland. Drifting further and further from the cognisance of Europe, Greenland, after the Eskimo invasion had stamped out the last of the Norwegian colonies, had ceased to exist so far as the rest of the world was concerned. Absolutely nothing had been heard of it for a century and a quarter prior to the arrival of Davis in 1585. Approaching from eastward, he searched the coast to the southward; then, doubling Cape Farewell, turned again north, left the ice behind, and saw green isles and fair water, and thought himself past all danger. The way seemed open to China!

We need not follow the intrepid seaman through all his perils and disappointments, either of this voyage or the two which followed. The third was the most productive of results, for this time he succeeded in reaching 73 degrees north latitude. Here he discovered Davis Strait, spelled with an "i," though its discoverer signed his name with a "y." Davis Strait washes the western coast of Greenland and connects Baffin's Bay with the Atlantic Ocean. Baffin's Bay, discovered in 1562, was still regarded as one of the fables of the navigator; it was not explored until 1612, when Davis had been seven years in his grave. Davis Strait was the greatest achievement of the gallant fellow whose name it perpetuates, and with it ended his quest of the impossible path across the weary waters to Cathay.

DR. DEE, JOHN DAVIS, AND ADRIAN GILBERT DISCUSSING THE NORTH-WEST PASSAGE WITH SIR FRANCIS WALSINGHAM

Davis made many subsequent voyages in different capacities, and was killed at last by Japanese pirates, who treacherously boarded his ship at Bintang. He was a daring navigator, skilful, bold, and original. He wrote of his voyages, and published a volume of sea-craft which had a wonderful circulation. To the end he maintained that a North-West Passage must exist. The sea cannot freeze, he urged; there is, and must be, a way round; the climate is possible in the higher Arctic latitudes—nay, desirable; and he pictured a race of people living at the

North Pole superior to the rest of mankind, through enjoying perpetual light "by the benefit of twilight and full moons." Davis died towards the end of December, 1605.

LOUIS DE BOUGAINVILLE
The First Frenchman to Go Round the World

Count Louis Antoine de Bougainville, born in Paris on November 11, 1729, was a man of many careers. The son of a notary, he was destined for the Bar, and practised as an advocate, but, having no taste for law, he devoted himself to science, and published a mathematical treatise. Then, finding science too quiet, he obtained a commission in the Black Musqueteers. He afterwards threw up soldiering for diplomacy,

LOUIS ANTOINE DE BOUGAINVILLE

and came to London as secretary to the French Embassy; and at last he put out to sea, and sailed and fought his way to the position of an admiral. He afterwards entered the political world, and became a senator and a Count of the Empire under Napoleon. In his younger days he was aide-de-camp to Montcalm at Quebec, and, on the death of his leader, he directed the retreat of the French troops.

The explanation of his widely varied career is that he was a born adventurer. He loved the race more than the prize, the struggle more than the victory; to him a successful adventure was an adventure that had lost its zest. He was one of those wild, swift, brilliant spirits that usually flash like a meteor and leave no trace. But he made his mark on the world by a mistake. The Peace of 1763 left him idle, and idleness was the one thing he could not bear. So he brought before a powerful Minister a plan for colonising the Falkland Islands, nearly at the south of South America, with French settlers from Canada, now conquered by England. A man of fine presence and great persuasion, he had sufficient influence at Court to get his way. Two ships were built for him at St. Malo, and on these he took several Canadian families to the Falkland Islands, which really belonged to Spain. Spain claimed them, and made good her claim, so that Bougainville's mad project at colonisation was exploded. But, in order to put to some use the last equipment prepared for him, he set out, in November, 1766, to circumnavigate the world and explore the South Seas.

He left the mouth of the Loire on November 15, 1766, in "La Boudeuse," a frigate of twenty-six guns, with a crew of 217 officers and men. Very leisurely he coasted down South America, gave an entertainment to the savages of Terra del Fuego, and went through the Straits of Magellan. On arriving in the South Seas, he touched at many of the islands, discovering some of the Samoa group, and surveying and fixing the position of other important lands. He then followed the coast of New Guinea and penetrated into the Indian Ocean, and, rounding the Cape of Good Hope, he arrived in France after a voyage of two years and four months. Being the first Frenchman to circumnavigate the world, he became very popular in his own country. He has the merit of discovering and reconnoitring some groups of islands little known before his time, but his fame is largely due to the charm and brilliance of his story of his voyage. In the American War he fought our ships off Martinique, was made vice-admiral in 1791, created a Count by Napoleon, and died, full of years and honours, on August 31, 1811.

JUAN DIAZ DE SOLIS
The Hapless Explorer of the South American Coast

Juan Diaz de Solis was a Spanish navigator who, in 1509, discovered the vast province of Yucatan, on the American mainland. The expedition, undertaken in concert with Vincent Pinzon, was not remarkable in itself, but it led to discoveries of the utmost importance. Two years later, Juan Diaz de Solis and Vincent Pinzon

sailed southward, and entered the mouth of the Amazon. They landed several times, and took formal possession of the territory, but on account of the small resources they had at hand they were unable to found any colony. The principal result of the voyage was the more exact knowledge it gave of the extent of the American continent.

De Solis was a skilful map-maker; it was by distinguishing himself in this respect that he emerged from obscurity. On returning from the Amazon, he was appointed the Royal Pilot, and afterwards entrusted with the supervision of naval charts. What he wanted, however, was to continue the exploration of South America in the hope of finding a passage to India. He thought it was impossible that the American mainland could extend far southward without a break. He expected the southernmost part would be a large island, with a quick and easy waterway to India and China.

In 1512 he set out on a voyage of exploration to South America from the point at which he had arrived with Pinzon. He anchored in the bay of Rio Janeiro, and, after exploring the coast of Brazil, discovered a vast arm of the sea, which he thought was the passage he sought. He took possession of the southern coast in the name of the King of Spain, and he called the water that stretched before him the Fresh Sea. Standing close to the land, he saw some Red Indians, who called the river Paranguaza, which means "great water." The Spanish explorer saw some traces of gold in the river, and gave his own name to it. But at the present time the Rio de Solis is better known as the River Plate.

De Solis sailed back to Spain, and obtained from the king the right to conquer the land he had just discovered. On October, 1515, he left the port of Lepe with three ships and sixty soldiers. Arriving at the River Plate, he set out to explore it more thoroughly, and ventured into the interior. The natives gave him a very friendly welcome, and offered him gifts. Full of confidence, he went on until he fell into an ambush, and was killed, with all the men that followed him. The scenes of cannibalism that ensued were dreadful, and, hearing of them, the Spaniards at once put out to sea, and sailed back to Spain.

BARTOLOMEU DIAZ

A Great Explorer who Saw, but Did Not Conquer

Bartolomeu Diaz, the Portuguese navigator who discovered the Cape of Good Hope, first appears definitely in history in 1486, when he was entrusted by John II. of Portugal with the task of finding out where the West Coast of Africa led. There is some hazy evidence as to his residence at Court, and association there with men of light and leading, who were dreaming dreams of empire in far-off lands, which lands must be reached by seaways not yet explored. Europe five centuries ago was in as complete ignorance as to what lay beyond a few days' sail of their own coastline as we were in ignorance until a short while ago as to the nature of the country round about the Poles. The condition is not so inconceivable when we recollect that, such was the horror of ocean-travel entertained by Japanese of a Japan men now living remember, that they had ships of such build that if they put out into the open sea, beyond the protection of their own shores, they must willy-nilly capsize.

Europe had hugged her own coasts, and not ventured beyond well-marked points. What lay along the West Coast of Africa no man knew; whether the coast led on indefinitely to that fabulous abyss, that gulf which the circumnavigator must "shoot" to reach the other side of the world, none could tell. The most southerly point known was what is now called Lüderitz Bay, in Namaqualand. Diaz was chosen by John II. of Portugal to get to the back of the beyond of this point, and see what happened. He sailed, in 1486, in two small ships, reached the "farthest south" known to his nation, and then for thirteen days ran before storms, out of sight of land. He might have turned sooner had he known, for he had outrun the continent. He turned east now, and was still on the wrong tack, so he steered north, and in 26 degrees southern latitude once more touched land.

After his long southerly run he had, by turning east and north, touched the southernmost point of Africa. Although he did not realise it at first, he was more than half-way round the then truly Dark Continent. He got as far as the mouth of what is now named the Great Fish River, half-way between Port Elizabeth and East London, on the south-east coast of Cape Colony, and then his crew, fearing that they were in peril of never seeing their homes again, insisted on his returning. Before he complied he clearly observed that the coast trended to the north and east; he had come down one side of Africa, and saw the corresponding coast running in the opposite direction before him, and he went home in triumph to tell the great news that the

way to the golden East lay open. On the way back he saw the Cape, past which violent gales had hurled him on the way down, and he called the spot the Cape of Storms, a name happily converted afterwards into the Cape of Good Hope.

For reasons which are not at this time obvious, when the expedition to India was fitted out, not the worthy Diaz but Vasco da Gama was appointed to the command. Diaz was responsible for fitting out the ships, and accompanied the expedition, under Da Gama, but was sent back by Da Gama to Portugal when they reached Cape Verde Isles. Again, when Pedro Alvarez Cabral was sent with a punitive fleet to exact vengeance for the massacre of Portuguese settled in the new-found India, Diaz was of the company, and was present in the wonderful adventure in which Cabral, seeking to avoid becalming off the coast of Africa, took too westerly a course, fell into the South American current of the Atlantic, and was carried to the coast of Brazil!

Diaz had set out to see the new empire in the East; he had lived to see Cabral proclaim a new one in the West, as he did without hesitation, before resuming his voyage to India. But Diaz was fated never to reach India. Terrible storms beset the fleet, seven of the twenty vessels foundered off his Cape of Storms, and he was among the lost. He had opened the seaway to India, but he was never permitted to see the land; he had explored nearly 1300 miles of coast unknown since the time of the ancients, but he died at sea, unrewarded, within a month of the taking of the westerly province which he had not set out to seek. His death occurred in May, 1500.

SIR FRANCIS DRAKE

The Great Sea-Rover of Elizabethan Days

Francis Drake was born, of obscure parentage, at Crowndale, near Tavistock, about 1540. The only indisputable fact as to his youth is that he was apprenticed to the owner of a small coasting vessel, and that his master, being childless, left the vessel to his apprentice. After some adventures on his own account in the coasting trade, he sailed to Guinea and the Spanish Main, and at twenty-seven commanded a small vessel, one of a little fleet fitted out by his kinsman Sir John Hawkins, who had the inglorious distinction of being the first Englishman to traffic in slaves. The expedition ended disastrously, all the ships save Drake's and another being destroyed by the Spaniards. At this time, and for many years afterwards, England and Spain were at peace so far as the two Courts were concerned, but at sea, or in distant ports, English ship fought Spanish ship, and English freebooters, of whom Drake was the most illustrious example, sacked Spanish towns and seized Spanish treasure without the faintest suggestion of hesitation.

All the Elizabethan sea warriors and navigators were neither more nor less than buccaneers; they fought and beat and despoiled their like in Spanish seamen, who in turn were buccaneers. Yet the two nations were nominally at peace! In the expedition noted, Drake got his first real taste of Spanish methods, and to his dying day he was repaying, and more than repaying, his enemies. Following the disaster to his fleet, Drake was sent by Hawkins to Court to complain of the treatment received, and succeeded in getting letters despatched demanding compensation for the injury sustained. Possibly no one would have been more disappointed than Drake had he succeeded. He made two voyages to the West Indies, apparently to spy out the land, and then set forth with two small ships, seventy-three men, three collapsible pinnaces, and in due season arrived at Nombre de Dios, the gathering-ground for all the treasure brought from Mexico and Peru to Panama to await shipment for Spain. Here he was joined by a third vessel, but her crew were left to guard the three ships, while Drake and his men went off in their pinnaces.

They attacked the city; they mastered the Spanish troops; they marched to the governor's house and found such stacks of silver, estimated to be worth a million pounds, that they could not carry it away; marching then to the treasure-house in which were kept the gold and jewels, they again found more than the pinnaces could carry. His men, fearing an attack while engaged in making themselves masters of the treasure, hung back. Drake, who was on the point of fainting from a wound, told them that he had brought them to the mouth of the "Treasure of the World"; if they would not have it, they must blame themselves. With that he ordered the door to be broken open, but swooned as he did so. His men carried him back to the boats, and the Treasure of the World remained untouched.

Upon recovering from his wound, Drake seized and burned Porto Bello, captured many Spanish ships, waylaid and seized vast treasure from overland caravans, and finally reached home with wealth enough to estab-

REACHING THE OPEN PATHWAY TO INDIA

BARTOLOMEU DIAZ, THE PORTUGUESE VOYAGER, ROUNDING THE CAPE OF GOOD HOPE AFTER SEVENTY YEARS OF FAILURE BY TIMID AND SUPERSTITIOUS SAILORS

lish him for life. But before he set sail for England he induced friendly Indians to lead him to the highest point of the isthmus of Darien (now Panama). There they pointed out to him a tree, from the top of which, they told him, he could see the North Sea by which he had come, and the South Sea towards which he was going. Drake climbed the tree, and there beheld on the one hand the Atlantic, and on the other the Pacific, or, as it is called at that point, South Sea. He was the first Englishman ever to view the stirring picture; and with that touch of romantic enthusiasm which never forsook him, even in his most violent moods, he "besought Almighty God of His goodness

SIR FRANCIS DRAKE

to give him life and leave once to sail in an English ship in that sea."

He reached home in 1573, was engaged with Essex in the operations against Ireland, and in 1577 sailed on his memorable voyage round the world. He took with him one ship of 100 tons, one of 80 tons, and three lesser craft. Of these, two were burnt as useless, one was swamped, and the other returned home. Only Drake's ship—which, setting forth as the "Pelican," was renamed "The Golden Hind" as she entered the Magellan Strait—only she compassed the voyage. Drake did not set out to circumnavigate the world; none but himself knew his intended course. His real purpose was plunder. But it is the most dazzling piratical expedition ever undertaken. After the straits were passed, they were driven for nearly two months out of their course by storms. With the advent of better weather they coasted along Chili and Peru, gathering enormous booty on the way. One ship alone, the "Cacafuego," yielded them gems worth £200,000, in addition to twenty-six tons of silver and eighty pounds of gold. Drake could now have returned home, and possibly would have gone back by the course followed outward, but that he feared another stormy passage. He decided, therefore, to cross the Pacific, and for sixty-eight days they sailed without sight of land. Passing the Moluccas and Java, and rounding the Cape of Good Hope, he reached Plymouth in safety, having in two years and ten months sailed round the world, the first Englishman to do so. He had been anticipated by Magellan's lieutenant alone.

Queen Elizabeth did not know whether she ought to honour him for having accomplished his feat, or to clap him into gaol as a pirate—"the master-thief of the unknown world," as honest critics named him. The Spanish ambassador clamoured for his incarceration, and the return to Spain of his booty. Finally, the Queen declared that Drake had but made reprisals for the damage done by Spaniards to English shipping; that the Spanish had no right to claim the American continent, and to debar other nations from colonising, or to warn the ships of other nations off the ocean. Moreover, if, as was reported, the treasure brought home by Drake was worth a million and a half, she had had to spend far more in suppressing rebellions in England and Ireland fomented by Spain. And then she went down to Deptford, whither the "Golden Hind" had been taken, dined with Drake, and knighted him, as the only man who had ever commanded a ship throughout a voyage round the world.

Afterwards Drake led other expeditions against the Spanish treasure-ships. His glorious share in the battle with the Armada is part of history known to every child. During his closing years he spent some few years on shore, acting as mayor of Plymouth, for which city he personally secured an ample water-supply, besides representing it in Parliament. His last expedition was to Porto Bello, which, nearly a quarter of a century earlier, he had burnt. He was seized with dysentery before he had achieved the object for which he had set out, and died, as was most fitting, on his ship on January 28, 1596.

THE GLORY OF THE SEA IN THE SEA'S AGE OF GLORY

A SHIP OF THE DAYS OF DRAKE—IN SUCH A VESSEL THE FIRST VOYAGE ROUND THE WORLD WAS MADE

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Drake was incomparably the greatest seaman of his age. He was a benevolent autocrat to his crews, and was regarded as a model of chivalry, for the time, in his treatment of his prisoners, though he held rich Spaniards to ransom. He was just and generous in his private dealings. Judged by the standards of our time he was one of the greatest pirates that ever lived, but it was an age of pirates; and his fellow-countrymen regarded him not as a filibuster but as a champion of their religion against the hated Spaniard. We must remember that there still lingered the memory of King Philip's brief stay in England as consort of Mary Tudor, and many a household was still mourning the victims of that misguided Queen's sanguinary methods of enforcing acceptance of the religion of Spain. Drake's mighty victories over the Spaniards were therefore balm to many a wounded heart; and as for his booty—well, had not the Israelites, with no better warrant, spoiled the Egyptians?

A BABY GORILLA AS SEEN BY DU CHAILLU IN THE AFRICAN FORESTS

PAUL DU CHAILLU

A French Traveller in the Heart of Africa

Paul Belloni du Chaillu was born on July 31, 1835, and educated first in Paris, and then at a mission station in the Gaboon, a French colony on the West Coast of Africa, between the Atlantic and the middle Congo. His father was the representative of a French trading house, and the boy, before his twentieth year, had attained a reputation on the strength of articles contributed to the American Press on travels he had achieved in the surrounding country. The result was that he was despatched by a learned society of Philadelphia on a mission of exploration, and for four or five years he did admirable work, travelling into the heart of the land of mystery, as the French Congo then was, describing the country, its people, and their habits. He covered about 8000 miles on foot, and published his results in a volume, "Explorations and Adventures in Equatorial Africa." The work was one of considerable importance at the time as a contribution to the literature of a subject but little known.

In the course of his book he dealt at length with the man-like ape now known to all the world as the gorilla. Although Andrew Battel, an English sailor who travelled in Guinea in 1590, had supplied

the world with an admirable account of the gorilla, which appeared in Samuel Purchas's "Pilgrimage," Du Chaillu was not believed. Eliminate from Battel's story his statement that gorillas beat and drive away elephants, and that "they go in bodies to kill many negroes," and his account of the gorilla might have been written yesterday. Scientists did not believe the admirable Andrew, and they did not believe Du Chaillu. A gorilla had never been seen in Europe; a live adult had not yet arrived, and possibly never might. They had only seen skulls and other parts of the skeleton, and they would have none of the travellers' tales concerning these terrible anthropoids.

As a matter of fact, Du Chaillu was himself partly to blame. When he treated of the natural history of the gorilla, man's savage likeness, he was absolutely accurate, but he adorned his story with "adventures" which to this day are not wholly accepted. Moreover, he proved untruthful in conversation when dealing with the matter. Thus when he brought a skin of an adult gorilla to England, desiring that it might be stuffed, it was pointed out to him that the skin of the face had been removed. Du Chaillu declared that this was not the case. "But it has been removed, and the face has been painted black," said the other. Seeing that he was trapped, the explorer admitted that he himself had painted the face of the animal when exhibiting the skin in New York.

Although the truth of all that he had written concerning the life of the gorilla was subsequently established by his own later travels, and the investigations of others, something of the original doubt concerning his work always remained, and the high value of his other contributions to learning, in their geographical, ethnological, and zoological aspects, was to some extent discounted. His fame never quite recovered the damaging criticisms of Huxley, who said, concerning Du Chaillu's work on the gorilla, "It may be truth, but it is not evidence." In later life Du Chaillu, who spent the greater part of the time in America, wrote well upon unfamiliar tracks in Northern Europe. He died at St. Petersburg on April 29, 1903.

EDWARD JOHN EYRE

A Great Traveller in Australia

Edward John Eyre was born at Hornsea, Yorkshire, on August 5, 1815. Like many other men famous in the story of the Empire, he was a son of the parsonage, and, as is the way with many parsons' sons, he aspired to a military career. Vexatious delays in getting a commission caused him to alter his plans, and at seventeen he sailed for Australia, and settled down to sheep-farming, first in New South Wales, and later in South Australia.

At this time Australia, to its settlers, did not represent an intelligible, comprehensible whole. They squatted on the margin, afraid to look at what lay inland. Access to the hinterland was difficult and arduous; their flocks and herds browsed upon the foreshore of the settlements, so to speak. A track through the Blue Mountains to the promised land of the pastoralist had indeed been found in New South Wales, but, for the rest, here was a continent with its coasts surveyed and mapped, but with its interior absolutely unknown land.

Oxley had penetrated to the swamps of the Lachlan River, and Sturt had disproved the theory that the whole interior was occupied by an inland sea. He had, moreover, discovered the greatest river of the continent, the Darling. The bold spirit of Eyre suggested that the people of the new colony of South Australia might learn something of the hidden features of their unseen land, and when he was twenty-five he began a series of daring expeditions into the interior. He had at twenty-one succeeded, like some patriarch of old, in driving his flocks by untrodden ways from New South Wales into South Australia, and he now sought a route by land from South Australia into Western Australia. With five white companions and three blacks he started from Adelaide to walk across half a continent. In order to get to the west he had to march due north by the head of Spencer Gulf. He found Lake Torrens a desert of brackish mud, and was unable to cross. He still pressed north for the westward turn, and two hundred miles of stony desert brought him to a second lake, which is now marked on the map with his name. The lake proved salt; a stream running into it was salt. The way to the west did not lie in this direction, and he could but return by the way he had gone. Setting out again, he took with him now only one Englishman, named Baxter, and three natives. His path this time lay along the head of the Great Australian Bight, a region so barren, waterless, and scorched by flaming heat as to appal all but the stoutest hearts. Thrice Eyre essayed a start, and thrice was beaten back by the conditions, but he

renewed his efforts a fourth time, and beat his handicap.

The journey is enshrined among the classics of exploration, for the conditions were such as have scarcely ever been mastered before or since. In a trackless barren waste, under a sun which rendered the rocks almost red-hot, which blistered the flesh and split the nails, and prevented the hair from growing upon his head, he battled his way westward, westward, westward. Water was always scarce, and found with vast difficulty, food ran short. Two of the three blacks turned traitor, and, seeking to rush the stores, were opposed by Baxter, whom they shot dead. And there in the wilderness was the traveller, with only one faithful black, and the other two constantly tracking him and seeking his life. So he struggled on until at last, to his infinite joy, he saw a ship lying off the coast, hailed her, and was taken off. He was carried to Albany, in King George's Sound, and thence back to Adelaide, a distance of 1036 miles, having carried out one of the most arduous and terrible journeys ever accomplished by an explorer. His travels had taken him over a year; and, though he had found no smiling land, he had marched valiantly out of South Australia into Western Australia. His record of the journey is among the works famous in the annals of exploration.

This and other expeditions, enabling him clearly to demonstrate that Australia possesses no inland sea, brought him the Founder's medal of the Royal Geographical Society. In view of that which was to follow, it is interesting to note that from an early age Eyre was a magistrate and an official, as well as private, protector of the aborigines. It was due very largely to his success with the natives that he was appointed, under the heroic Sir George Gray, Deputy-Governor of New Zealand, where the Maori question was the most difficult that our fellow-countrymen had to handle. Other Colonial posts followed, and in 1864 he was appointed Governor of Jamaica. Here occurred the tragic events which embittered the whole of Eyre's after-life, and divided England into two camps, for and against him.

In the critical days that followed the emancipation of the negro slaves, feeling ran high in the West Indies. The planters were sore at the reverse of fortune sustained by the restoration of human rights to their poor living chattels; and the spirit of the negroes was expressed in one of the songs they sang before the day of freedom.

THE ARRIVAL OF EYRE AND HIS NATIVE ATTENDANT AT KING GEORGE'S SOUND

But 'mancipation come, ha, ha!
Den me wear massa's coat, ha, ha!
Me kiss him wife;
Me steal him knife,
And cut his ugly throat, ha, ha!

In 1865 there occurred a negro uprising in Jamaica which undoubtedly had its rise in some such instinct as the old song implies. The Europeans in the island were few; the negroes were many, and the setting up of a negro republic was much in the air. Moreover, the negroes were suffering from certain real grievances which, in the circumstances, were unavoidable. Following an outbreak in which twenty whites were killed and many wounded, disorder and bloodshed became widespread in the

island. The rising was suppressed with merciless severity under proclamation of martial law in defined areas.

The figures are appalling even at this date. Upwards of 600 were killed in action or executed, and, in addition to many wounded, 600 negroes, including some women, were flogged, while over a thousand negro dwellings were destroyed. But the agitation against Eyre was focussed in the main upon one special incident. A wealthy mulatto named Gordon, a Baptist and a member of the local Legislature, was accused of having fomented the outbreak. He was seized in a district to which martial

THE LAST STAGE IN EYRE'S JOURNEY

law had not been extended, carried to one in which it had, was tried before the military authorities by court-martial, and sentenced to death. Eyre confirmed the sentence, and the execution was carried out. The case was at once taken up in England; a Commission found that Gordon had been convicted on insufficient evidence, and, while commending the promptitude with which Eyre had at first dealt with the outbreak, condemned the severity and illegality of certain other acts which had followed.

Eyre was recalled, to find himself the centre of a bitter controversy. Public opinion was sharply divided on the question. Against him were John Stuart Mill, Huxley, Thomas Hughes, Herbert Spencer, and Goldwin Smith; while among his stoutest defenders were Carlyle, Ruskin, Tennyson, Kingsley, and Sir Robert Murchison. Legal proceedings were taken, but Eyre was twice discharged, and finally the Government refunded the costs of his defence while Disraeli conferred a pension upon him. Eyre retired into private life, and was forgotten as a man of his time, being regarded, like Don Pacifico, as a mere name in history. But in private he kept in touch with the world; and only a few months before his death, which occurred on November 30, 1901, wrote a letter to the editor of the present publication, demonstrating in poignant terms that he desired, if no longer of the world, at least to be remembered as still being in it.

SIR JOHN FORREST
Australian Explorer and Statesman

Sir John Forrest was born at Bunbury, on August 22, 1847, the son of a Scottish civil engineer, who emigrated to Australia in 1842. Better known of late years as one of the foremost statesmen of the island-continent, Sir John Forrest, in earlier days, when the veil that hid the heart of Australia was being drawn aside, was famous among the most daring and successful of explorers. Trained from his youth to the wild, free life of the bush, for the primitive conditions of the old convict Swan River Settlement had not then departed, he was admirably fitted for the work that lay before him, while his experience in the Government Survey Department at Perth was in itself a scientific education of the highest value. His work as an explorer was inaugurated under tragic conditions.

Twenty-one years earlier, Ludwig Leichardt had set out to explore the continent from east to west. Silence closed about him in April, 1848, and from that day to this no trace of his expedition has been found. Forrest, in 1869, when twenty-two years of age, was appointed to lead an expedition into the wilderness in search of any remains of the missing men. The quest was vain, but the young explorer marched with discerning eye through an unknown land, through almost impenetrable bush, through seemingly endless salt marshes, undaunted by heat and thirst and privation. He passed over one of the richest of Australian goldfields, ignorant of the treasure that lay beneath his feet—over what is now the

Coolgardie and Kalgoorly mining district, then an inhospitable waste, now a busy hive of industry, with a railway, a place to which one of the most surprising of artificial water-supplies has of late years been carried.

Although he failed to attain the object of his enterprise, Forrest proved his fitness for more ambitious undertakings. There was work for many to do, but the men capable of undertaking it were all too few. He was gifted by Nature for the work; and, within a year of his initial exploit, made the journey from Perth to Adelaide, following along the Great Bight, the cruel coast route that had so nearly brought Eyre to his death. He was not seeking sites for homes, or opportunities for making wealth; he was surveying a savage wilderness in order that man might speak to man from colony to colony, though barren desert and waterless wastes stretched between them. And where he marched the telegraph has, in consequence, followed.

His third venture was his greatest. This was an expedition from Champion Bay (now Geraldton), on the west coast, to the overland telegraph which links the north of the continent, at Port Darwin, with the south of the continent at Adelaide. This journey amounted to 2000 miles. It was performed through country of the most inhospitable character, and under circumstances of special disadvantage. Forrest had no camels, but was compelled to rely upon horses, whose watering was a matter of extreme difficulty in a country that was almost entirely desert.

Forrest handled his expedition with consummate skill, returned in safety, and presented admirable reports and maps. His success brought him the gold medal of the Royal Geographical Society, while Sir Frederick Weld, Governor at the time of West Australia, writing of the feat to Lord Carnarvon, said, "Mr. Forrest's expedition has bridged the gap that separated Western Australia from the other colonies, has led to settlement on the shores of the Great Bight, and to the connection of this colony with the rest of the world by the electric telegraph. I never doubted of the future of Western Australia from the day when the news of Mr. Forrest's success reached Perth."

Subsequently, Forrest carried out important scientific surveys over the lands he had crossed in haste, was rewarded with a seat in the Legislature, and with a grant of 5000 acres of land. Since then he has been Premier of his native colony, and has held high office in the Commonwealth Government. His enterprising statesmanship is reflected in the development of his colony, where the fine harbour of Fremantle, and the colossal scheme of artificial waterworks for the Coolgardie goldfields, are monuments to his energy and acumen.

The last-mentioned undertaking is specially interesting in view of the hardships which he and other pioneers had suffered in the waterless ways of Australia. Residents in the Coolgardie goldfields found it impossible to use even such scanty water as was available on the goldfields without first condensing it; its alkaline properties made it useless either for drinking or for industrial uses without first undergoing this process. The consequence was that every gallon of water used on the goldfields cost twopence, or £2 per ton; and Coolgardie was largely unwashed. Sir John Forrest's scheme gives the goldfields a supply of six million gallons a day, at 5 per cent. of the former cost. The water is carried, through thirty-inch pipes, 325 miles from the River Helena, and is raised, during its course, by eight sets of pumping-stations, to a height of 1400 feet above sea level, or eleven hundred feet above the level of the river at the spot whence the water is derived. Sir John Forrest has written of his travels, and his volumes are included in the classic records of Australian exploration and heroism.

SIR JOHN FRANKLIN

The Hero of the North-West Passage

Sir John Franklin, who with his life forged the key to the North-West Passage, was born at Spilsby, Lincolnshire, on April 16, 1786. His family had been "franklins," or yeomen, of Lincolnshire for many generations. He was the youngest of a family of twelve, and was intended for the Church, but there was in his blood that elixir which drives men forth from the serenity of peaceful homes to seek their bread amid the perils of the waters, or in the inhospitable wilds of distant lands. At fourteen, then, he was sent to sea, straight from the Grammar School of Louth, and as a boy of fifteen he was in the ship that led the van at the battle of Copenhagen, while at nineteen he passed scatheless through Nelson's crowning engagement. Meanwhile he had had a three years' surveying trip to Australia with his kinsman, that fine character Captain Flinders, and under the influence of Flinders, and of Robert Brown and Ferdinand Bauer, the botanists on board, imbibed a passion for

scientific inquiry and accurate observation which determined his after-career.

With the restoration of peace, the thoughts of men were turned again to the age-old question of that magic passage, by the north-west of the American continent, to the riches of the East. From the day when Englishmen had cast off the cables that bound them to home waters, they had thought this passage was easily to be accomplished. The valiant Davis, who in the sixteenth century had discovered and christened the strait that bears his name, had written that the thing was practicable, and, indeed, not difficult. It was so simple a matter, in the minds of courageous men,

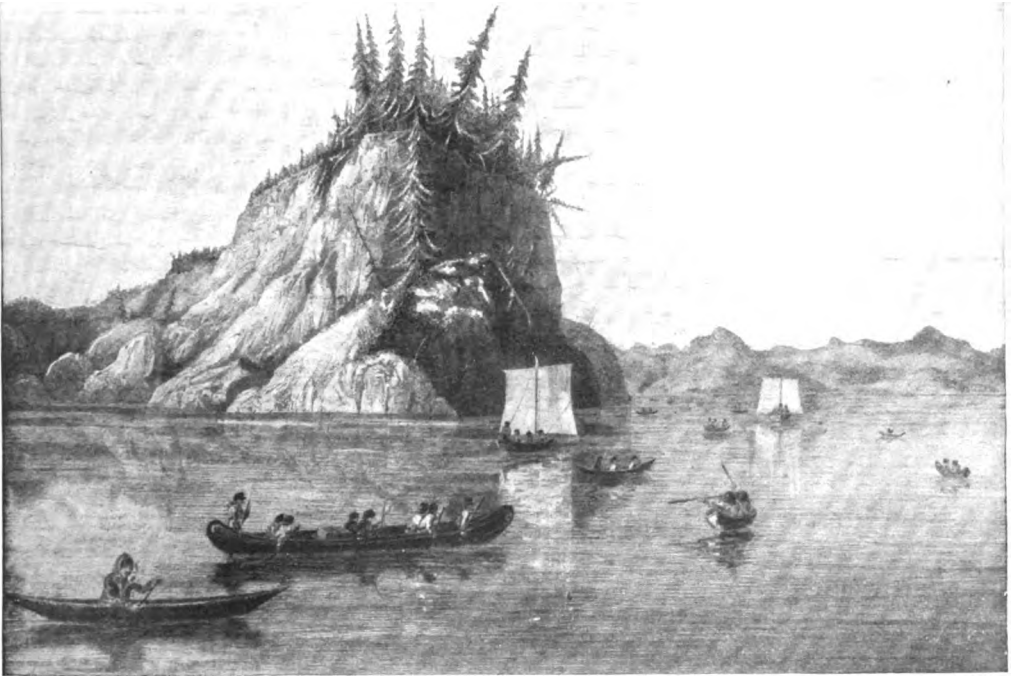
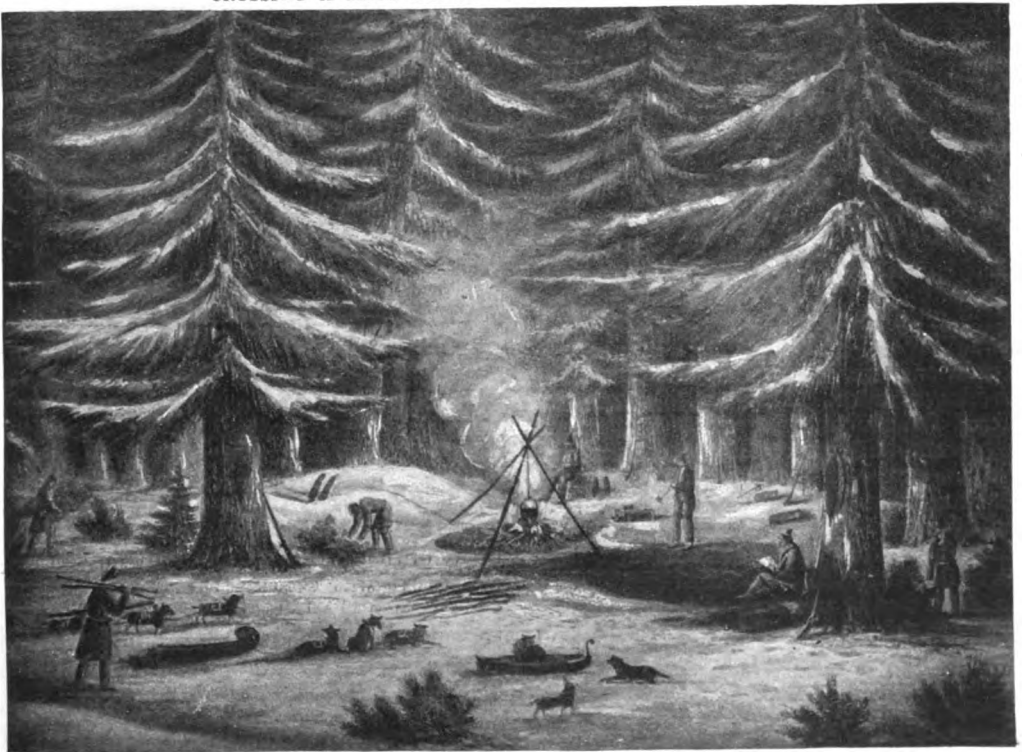
SIR JOHN FRANKLIN

that Drake, after he had loaded his "Golden Hind" with Spanish treasure off the coast of South America, balanced in his mind two propositions: (1) To return home by way of the Straits of Magellan, and (2) to slip through that much-talked-of passage from the Pacific to the Atlantic, along the north of the continent. He thought so little of the difficulties of the latter that he would have preferred it to the dangers of the stormy ways by which he had come, had not the crew shown a decided distaste for high northern latitudes.

The popular belief was that land ended in the north on the one side at Cape Wolstenholme, the promontory that guards the easterly entrance to Hudson's Bay, and, on the other side of the continent, somewhere about the latitude of Vancouver. They had only to find the way round, they thought, to sail from ocean to ocean without a care. Cook's voyage along the west coast of North America for ever settled that point, for he coasted hundreds of miles past the point at which land has been supposed to cease. Forty years after Cook's exploit the search for the opening began again, and Franklin was given command of one of the ships sent out to try what the waters of Spitzbergen offered. The voyage revealed Franklin's high abilities for such work, and in 1819 he was placed in command of an expedition whose duty was not to attempt the actual Passage, but to survey the mysterious coast-line of farthest North America. The task was accomplished in three and a half years, during which the party endured terrible hardships.

Franklin thoroughly surveyed the banks of the Coppermine River, and explored the coast from Coronation Gulf, six hundred miles to the eastward. He returned to England with a record of over 5500 miles of land and water mapped, was made a post-captain, and elected F.R.S. The second expedition under his command explored the Mackenzie River, and traced the coast to near the 150th meridian. It is interesting to note that on this occasion Captain Beeching was sent round by the north-east to join hands with Franklin, and got within fifty miles of him before being laid up by ice. By that tiny margin was the Passage missed. Franklin upon his return was knighted, and, already a widower, married as his second wife Miss Jane Griffin, of whom the world was afterwards to hear much.

Sixteen years passed away, in which time Franklin was engaged in the Greek war of independence, and afterwards acted with signal success as Lieutenant-Governor of Van Dieman's Land. Then, in 1845, came another proposal to find the North-West Passage, and the command was offered him. While negotiations were proceeding the First Lord remarked upon his age. "My lord, I am only fifty-nine," answered the dauntless hero. Franklin's previous experience and instinct for direction told him that the secret way lay westward from the mouth of Fish River to Behring Strait, and his instructions bade him follow that route. He did, and died a few miles to the west of the point reached by the most successful of the voyagers who had essayed the North-East Passage. By proving the existence of a waterway he discovered the long-

FRANKLIN'S FIRST VISIT TO POLAR SEAS

CROSSING A LAKE BEFORE REACHING PERPETUAL SNOW

THE EXPEDITION CAMPING IN A NORTHERN FOREST

sought North-West Passage, though whether he knew it we shall never know.

Of the 134 chosen officers and men who manned the "Erebus" and "Terror," not one came back alive. The ships were spoken by a whaler on July 26, 1845—nine weeks after they had said good-bye to England at Greenhithe. They were then in Melville Bay, on the west coast of Greenland. The men who sailed there were never again seen alive, save by Eskimos, who found them staggering along, dropping dead as they walked. But all this took years to learn. Three years of waiting brought no tidings, and the public mind, agitated by Lady Franklin, became alarmed. Ten expeditions were sent out without discovering a trace. Then the Government offered £20,000 for the rescue, and £10,000 for definite tidings as to the fate of the hapless explorers. Year after year the search went on. Ship after ship went out, and lives were lost and ships wrecked. Ten years the search lasted, and in that time thirty-five expeditions, English and American, at a cost of upwards of a million sterling, sought to elucidate the sorrowful mystery. Little by little the story was pieced together, and M'Clintock, in the "Fox," fitted out practically at her own expense by Lady Franklin, finally cleared up the tragedy.

Franklin's ships were imprisoned in the ice bearing down from the west, through the then unknown M'Clintock Channel, upon King William Land. They remained beset, drifting thirty miles with the ice in two years. How Franklin died will never be known. A record was found in a cairn at Point Victory bringing the dismal story down to April 25, 1848, in which it was stated—"The 'Erebus' and 'Terror' were deserted 22nd April, 1848, 5 leagues N.N.W. of this, having been beset since 12th September, 1846; officers and crews, 105 souls, under Captain Crozier, landed here . . . Sir J. Franklin died 11th June, 1847." The crews apparently set out on foot to reach help at a fort on Hudson's Bay. Some went on to die, others returned to die; many expired by the wayside. Franklin died without knowing the worst. He was spared sight of the agonies and madness whose evidences were found by Dr. Rae. "From the mutilated state of many of the corpses, and the contents of the kettles, it was evident that our wretched countrymen had been driven to cannibalism as a means of prolonging existence."

THE ARCTIC BURIAL PLACES OF SOME OF THE COMRADES OF SIR JOHN FRANKLIN

Many relics and bodies were found, but not the body of Franklin, who, with those who died in the early stages, were buried by their comrades. Others were found lying where they had fallen, in their tents, under

upturned boats, with guns in their hands ready loaded for the game that never came. The very prints of their snowshoes were clearly discernible in places; stacks of useless impedimenta carried from the ships were found where men, approaching death, had dropped them; a pair of gloves, still weighted by stones to prevent their blowing away, were discovered where they had been placed after being washed.

This discovery of the North-West Passage, finally achieved in this search for the dead, was our greatest triumph in the Arctic, but it was purchased at the heaviest price we have ever paid in such work. When, with the passage of time, grief for the dead was somewhat assuaged, the Royal Geographical Society bestowed the Founder's gold medal upon Lady Franklin as a testimony of "the gallant services rendered to science by her late husband, and also as a token of respect and admiration for the devotedness with which she has pursued those inquiries which have resulted in clearing up the fate of the crews of the 'Erebus' and 'Terror,' and at the same time in making many important contributions to our geographical knowledge of the Arctic regions." Franklin's monument, erected in Westminster Abbey, is pathetically inscribed: "Erected by his widow, who, after long waiting and sending many in search of him, herself departed to find him in the realms of life."

SIR MARTIN FROBISHER
A Follower of the Lure of Gold

Sir Martin Frobisher was born at Altofts, Normanton, in the West Riding of Yorkshire, some time between 1530 and 1535. Left fatherless at an early age, he was committed to the care of a kinsman in London, who, in 1554, sent him to sea. During the next few years Frobisher made many voyages, and we hear of his being called upon to answer a charge of having fitted out a ship as a pirate. He becomes a national figure with the launching of a scheme for the discovery of the North-West Passage to Cathay and the Indies. This was not a new scheme, but the famous "discourse" by Sir Humphrey Gilbert gave the project a definite character. It was taken up by some of the wealthy London merchants, by the Earls of Warwick, Leicester, and Sussex, by Burleigh, Walsingham, and Sir Philip Sidney, who between them managed to get together £875, which in our present currency would represent about £7000.

Frobisher was appointed to command, and with two little barques, each of about twenty-four tons, he sailed in June, 1576. Off the northern coast of Labrador a great storm arose, and separated the ships. One, thinking that Frobisher had been wrecked, returned home, while Frobisher, with only eighteen men, continued his way to the south of what we now know as Baffin Land, but which he, or Queen Elizabeth for him, named Meta Incognita. He discovered the bay that bears his name; and as it is twenty miles in breadth and 200 miles in length, it is not surprising that he should regard it as a strait. Beyond its northern limit, he thought, lay the real way out. But ice and contrary winds barred his path; and as he lost his pinnace with five men, and so was reduced to a crew of thirteen, he deemed it expedient to return.

Probably we should have heard nothing more of him in this connection but for a specimen of black ore brought back as a memento. This was declared by a London alchemist to be gold. The fruitless voyage, when this became known, was at once exalted into a triumph. The piece of "black earth" and a live Eskimo were the sole products of the expedition, but when the story got abroad Frobisher was "joyfully received with great admiration of the people, and their strange man and his boat as such a wonder to the whole city, and to the rest of the realm that heard of it, as seemed never to have happened the like great matter to any man's knowledge."

All turned, now, upon the piece of ore. A Company of Cathay was formed, with Frobisher as captain-general and admiral. The Queen furnished a ship and money, expecting a rich return in gold, for, though the second expedition was nominally for the purpose of forcing a passage to old Cathay, Frobisher's real instructions were "for the searching more of this gold ore than for the searching any further discovery of the Passage." Was Frobisher deceived by the alchemist's report as to the nature of the ore? The London goldsmiths pronounced unequivocally against the worth of the "black earth." Was Frobisher himself deceived when he told Sir Philip Sidney that "the island is so productive in metals as far to surpass Peru"? Or was he a party to, or originator of, the deception, in order that he might obliquely stimulate support for the scheme of exploration on which his valiant heart was set? Be that as it may, although on returning to his Meta Incognita he did take up a consider-

able quantity of ore, he explored the coastline, took possession of the land in the name of the Queen, and made a survey of Jackson's Sound. Not much for a Frobisher, but still enough to suggest that he was out for more than gold.

The ore taken back was declared to be "poor in respect of that brought last year, and of that which we know may be brought next year." There is a masterly touch in the last phrase, for it induced confidence in the new expedition then preparing. The Queen received Frobisher at Greenwich, put a chain of gold about his neck, and believed with all her heart that gold unlimited would be derived from the new lands. Preparations were made for the fitting out of fifteen ships; and although the 200 tons of ore brought back at the second attempt had by this time proved worthless, the great Lord Burghley desired that full 5000 tons should at the next venture be secured. Nay, more; the land was to be colonised; a hundred people were to be established under the English flag in Meta Incognita. The project seems utterly mad today, for Baffin Land, of which Meta Incognita is the southern extremity, is barren, and gripped, for the greater part of the year, by ice-locked seas. But gold was the lure—gold, and the chance of "annoying" the Spaniards and the Pope who had taken upon himself to give them all the Western world.

Sidney, who was again a shareholder, as was his sister, the Countess of Pembroke, saw in the venture not merely potential wealth but the probability that "at some time or other it may be of use to the professors of the true religion." So on May 31, 1578, forth sailed Frobisher with his fifteen vessels, and his 100 colonists, leaving envious hearts behind him, so that a valued correspondent of Sidney wrote him at the time, fearful of the effect in unsettling the popular mind and starting a general stampede to the Arctic, "In old times, when some Carthaginians, on a voyage in the Atlantic, had been carried by a storm to land of some sort, and had come back with wonderful reports of its wealth, the Senate, fearing the people would be tempted to go thither, put to death the men who had brought the report, so that if any wished to emigrate they should have none who could guide them."

Frobisher touched on the south-west coast of Greenland and effected a landing. The Vikings had colonised part of the land while England was still Saxon, but the history and memory of it had vanished, and Frobisher, finding the place a sterile wilderness, contented himself with naming the whole West England and a conspicuous headland Charing Cross. Then he pushed out westwards. The ships became scattered, and Frobisher sailed before a storm sixty miles up a waterway new to him, which was later to be named Hudson Strait. He was on the track of a North-West Passage.

He turned back with some reluctance, exploring the coastline as far as Meta Incognita, and seeking in vain for a habitation for his colonists. Having explored the upper reaches of Frobisher Bay, he loaded up with ore, and returned. Before doing so he landed a quantity of stores, which he intended to use in the following year. Those stores lay untouched for nearly three centuries, when Captain C. F. Hall, of the United States, who spent five years among the Eskimos searching for Sir John Franklin, found them where they had been left by the tough old sea-dog so long before. That ended Frobisher's Arctic work. His vast load of ore proved too valueless even to smelt; the vision of an Arctic Peru faded.

SIR MARTIN FROBISHER

All that Queen Bess got out her venture was the horn, or spiral tooth, of a narwhal, but it was compensation enough, perhaps, for her, for the narwhal's "horn" was regarded then as the horn of the veritable sea unicorn, and possessed of magic properties inestimable. It was "reserved as a jewel by the Queen's majestie's commandment in her wardrobe of robes," but the value of the "jewel" lay, we know, in its fancied occult virtues. Frobisher turned from exploration now to fighting, and for his part in the defeat of the Armada was knighted. His value for us, however, is linked with the Arctic. He did notable work under difficulties. He made geographical mistakes, like all his successors. He mistook bays for open seas, open seas for bays, and islands for the mainland. But so did they all. The map of northernmost America is a record of multitudinous blunders, paid for with many precious

lives. Frobisher sailed by the charts of Antonio and Nicol Zeno—two Venetians who, out for the North-West Passage, visited Greenland, Newfoundland, and the northern part of America in the fourteenth century, and made their maps and left them to posterity. The Vikings made no maps; the actual sea with its gods and demons of a rich and varied mythology was all the chart they knew. Frobisher and those that came after had bad charts or no charts, and he, like his Viking forerunners, was of the school that marked the way of travel with dead men's bones.

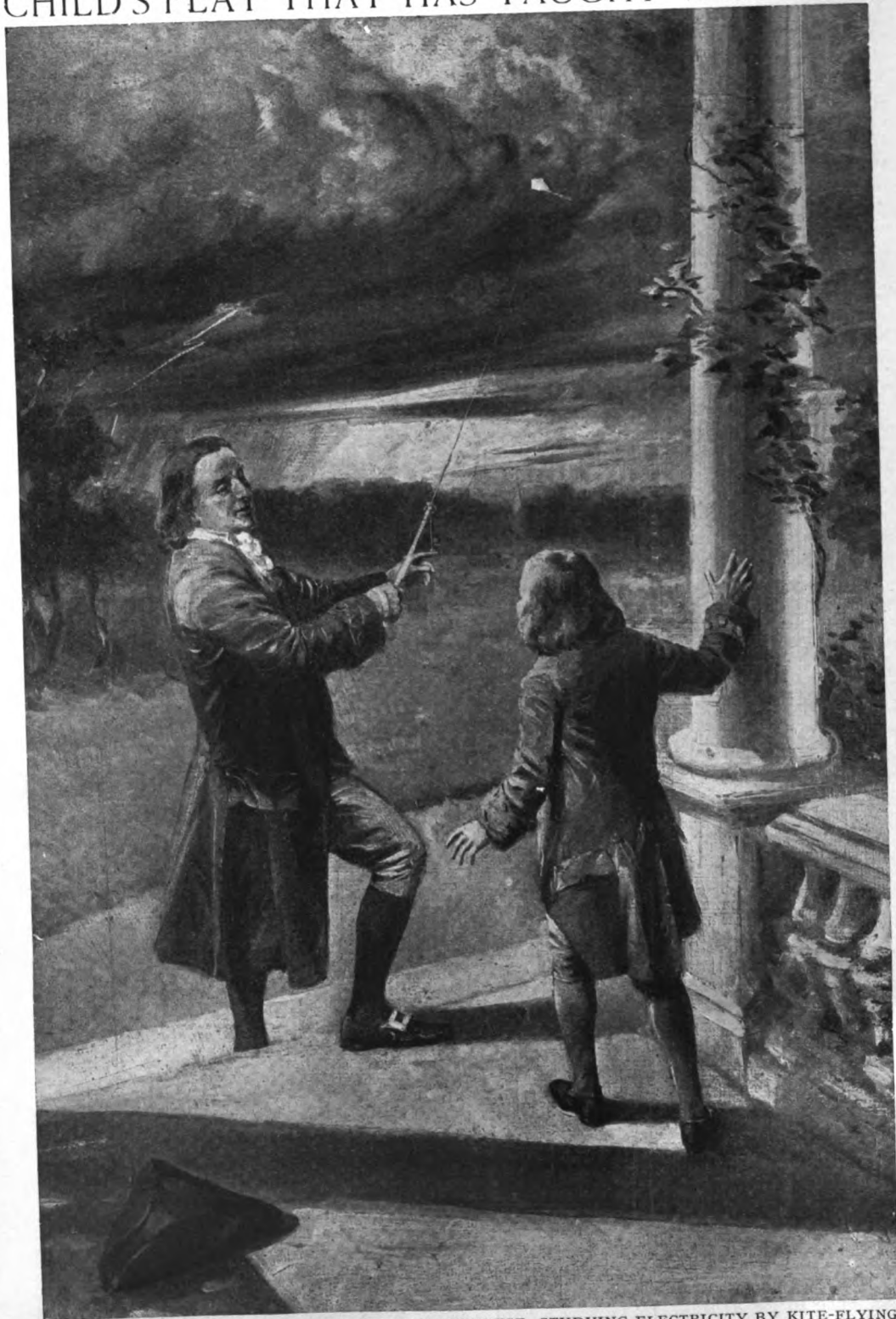
He is not to be compared with Franklin, or with some of the lesser men who sailed undaunted into those terrible seas of death, but a glamour and romance attach to his enterprises which can never fail to fascinate so long as the records of our Elizabethan giants are read. Frobisher, who was twice married, and was to the last as ardent a pirate as he was a Protestant, died on November 22, 1594, from wounds received in a fight with the hated Spaniard off the port of Crozon, near Brest.

SIR HUMPHREY GILBERT
Who Planted the First English Colony in America

Sir Humphrey Gilbert, the first of our empire-builders, was born at Compton, near Dartmouth, about 1539. Sir Walter Raleigh was his half-brother, Mrs. Gilbert marrying again on the death of Humphrey's father. Humphrey was thirteen years older than Walter; and it was from the older boy, who showed in youth a passion for the study of navigation, that the founder of Virginia and the discoverer of Guiana received the inspiration for his great achievements. The early part of Sir Humphrey's career was spent in fighting in France, Ireland, and the Netherlands, and he won the honour of knighthood and the governorship of Munster.

But his interest in maritime discovery was greater than his taste for land warfare. He studied map-making, and invented a spherical instrument with a compass of variation, as a more exact means of navigation than the ordinary sea cards then used by sailors; and at twenty-seven he presented to Queen Elizabeth a plan for exploring the North-West Passage to China. He was then too useful in Ireland for the Queen to spare him, but the publication of his plan some time afterwards led to Frobisher undertaking the adventure. Frobisher's first successful voyage inspired the Queen and her Ministers with more confidence in Sir Humphrey Gilbert's skill in maritime discovery, and in 1578 he was granted letters patent for planting an English colony in America. Sir Humphrey sank all his fortune in the enterprise, and induced a large number of gentlemen adventurers to join him. But when the fleet put to sea, in 1578, quarrels broke out among the volunteers, each ambitious of power, and the unorderly crews were struck by a tempest in the midst of their dissensions, and attacked by the Spaniards. A fine ship was lost, and everybody disheartened, and Gilbert returned to Devon a ruined man.

His letters patent only ran for six years. He was resolved to found an American colony before his powers expired. He raised some money by assigning some of his colonising rights in Canada, and collected another body of adventurers, and even emptied some gaols in order to get settlers for his new land. At last, on June 11, 1583, he sailed from Plymouth with 260 men and five ships—the "Delight," "Golden Hinde," "Swallow," "Squirrel," and the barque "Raleigh." The last vessel was provided by Sir Walter Raleigh, and he was on board; but after going some way he pleaded that sickness had broken out on his ship, and returned with her to England. Perhaps he did not like playing a subordinate part in the enterprise, for the next year he fitted out a fleet himself, and took possession of Virginia.

At the end of seven weeks, Sir Humphrey, with the other four ships, arrived at Newfoundland, and, finding the soil of the country fertile and well wooded, he decided to plant his first colony there. The English cod-fishers were already the strongest power at the Banks, and they welcomed the colonists and feasted them continually. But the gaolbirds that Gilbert had brought with him soon began to misconduct themselves. They plundered a fishing-barque, and then fled to the woods and plotted to steal some of the ships. In the meantime, Gilbert set out with three of the ships on a voyage of exploration to Nova Scotia, but his largest ship was wrecked off Cape Breton. Bad weather and troubles with the criminal party of his men were more than he at last could cope with. "Be content; we have seen enough!" he exclaimed. "I will set you forth royally next spring, if God sends us safe home!" But he never reached home. Sailing with two of his ships back to England, he was caught in a storm off the Azores on September 9, 1583, and his small vessel went down with all hands.

BENJAMIN FRANKLIN, THE FIRST AMERICAN SCIENTIST, STUDYING ELECTRICITY BY KITE-FLYING

CONTINUED FROM 4543 CONTINUED ON 4773

THINKERS

DESCARTES

The Timid Man who Re-established the Dignity of Thinking

René Descartes (or Des Cartes), the champion of reason, was born in Touraine, of Breton parents, on March 31, 1596. His consumptive mother died of consumption a few days after his birth, and the feeble boy's life was continually despaired of. But he survived, and " in his eighth year had gained the title of the young philosopher, from his avidity to learn and his constant questioning." The Jesuits taught him, and took natural delight in their astonishing young pupil. But when he left their college he declared that he " had derived no other benefit from his studies than that of a conviction of his utter ignorance, and a profound contempt for the systems of philosophy in vogue." Hence, he tells us—and this is all the thanks his instructors got for their pains—" as soon as my age permitted me to quit my preceptors, I entirely gave up the study of letters; and, resolving to seek no other science than that which I could find in myself, or else in the great book of the world, I employed the remainder of my youth in travel."

But he did not waste his time, even though he did some soldiering, and talked and lived with all sorts and conditions of men. He was steadily thinking all the while. At thirty-three he secluded himself in Holland, not allowing even his friends to know where he was, and after eight years he produced, in 1637, his world-famous book the " Discourse on Method." This and its successor, the " Meditations," upon which he asked for criticism, made his name famous throughout Europe. The Dutch theologians were aroused against him, and he went to Sweden, at the invitation of Queen Christina, in 1649.

Descartes was perhaps the most illustrious champion in our era of the claims of reason, and of its power to solve the problems which had usually been left to faith. Authority declares that we must believe in the existence of God; Descartes declared that reason could prove it. He is the father of modern philosophy; the modern master of deduction, as Bacon was the master of induction. He was not an observer, but a deducer. He left to others the erection of general truths upon detailed facts, which we call induction. His mind was essentially mathematical. He was, in fact, a mathematical genius of the first order, and may be said to have founded analytical geometry. He would be one of the greatest mathematicians of all time even if he had never written at all upon philosophy.

The certainty and potency of mental processes in mathematics explain the confidence felt by Descartes in the method of deduction, and his native endowment explains the mastery with which he used his method, so that Cartesianism has become recognised as one of the few greatest products of the human mind.

He rejected, as we have seen, the teaching of the schools. A fresh start was required, and Descartes determined to make it. The only possible beginning, he said, was with the thinker's own only certainty—" Cogito, ergo sum; " I think, therefore I am. We must begin with what our own consciousness clearly affirms, and we must trust what it thus affirms. Hence the second great assertion or principle of Cartesianism, that *all clear and distinct ideas are true*—an axiom which its author calls " the foundation of all science, the rule and measure of truth." From this proceeded his famous demonstration of the existence of God, which is, indeed, none other than the assertion that he found in his mind a clear and distinct idea of God, from which it followed that God must exist. We may doubt whether these arguments are worth quoting now, except for their historical interest, but they made a

profound impression upon the thinking world in the time of Descartes, and have been discussed by philosophers ever since.

In some ways more important are the speculations of Descartes in matters of physics and physiology. His application of algebra to geometry, which made an epoch in mathematics, need not here concern us, but we must look at the results which he obtained when he began to reason upon the functions of the animal body in terms of his mathematico-mechanical ideas. We owe much to Huxley as a recent commentator upon Descartes in this respect, writing with physiological knowledge upon the speculations of the thinker who wrote before

DESCARTES

physiology can be said to have come into existence. A great contemporary of Huxley, Professor Tyndall, reviewing "Huxley's admirable Essay on Descartes," writes of the French philosopher—

"He was the first to reduce, in a manner eminently capable of bearing the test of mental presentation, vital phenomena to purely mechanical principles. . . . He sketches with marvellous physical insight a machine, with water for its motive-power, which shall illustrate vital actions. He has made clear to his mind that such a machine would be competent to carry on the processes of digestion, nutrition, growth, respiration, and the beating of the heart. It would be competent to accept impressions from the external sense, to store them up in imagination and memory, to go through the internal movements of the appetites and passions, the external movement of limbs. He deduces these functions of his machine from the mere arrangement of its organs, as the movement of a clock or other automaton is deduced from its weights and wheels. 'As far as these functions are concerned,' he says, 'it is not necessary to conceive any other vegetative or sensitive soul, nor any other principle of motion or of life, than the blood and the spirits agitated by the fire which burns continually in the heart, and which is in nowise different from the fires which exist in inanimate bodies.' . . . The boldness, clearness, and precision with which he grasped the problem of vital dynamics constitute a marvellous illustration of intellectual power."

Animals, in fact, are automata, according to Descartes, though he did not dare to apply his conclusions to man, in whom, according to him, there operated a soul which acted through or in the "pineal gland" of the brain. Here we see, as in many other instances, a certain cowardice in this remarkable thinker. As G. H. Lewes says, "In disposition he was timid to servility. When promulgating his proofs of the existence of the Deity he was in evident alarm lest the Church should see something objectionable in them. He had also written an astronomical treatise, but, hearing of the fate of Galileo, he refrained from publishing, and always used some chicane in speaking of the world's movement. He was not a brave man; he was also not an affectionate one."

Throughout his life he was delicate, and doubtless his incessant study was pursued at the expense of his health. Stockholm was hardly the climate for him, and one morning, on a visit to the Queen, he contracted a pulmonary inflammation which killed him on February 11, 1650. His body was buried in Stockholm, with a long eulogy, by order of the Queen, but since 1666 it has lain in Paris. His philosophy has since undergone many vicissitudes, but his contributions to mathematics remain assured.

HENRY DRUMMOND

An Evolutionist in the World of Morals

Henry Drummond, whose writings have brought spirituality into evolution, was born at Stirling, on August 17, 1851, and was educated at the High School of that

town before entering Edinburgh University at the age of fifteen. From the first, the idea of his friends was that he would become a minister, and to that end he eventually studied at the Free Church of Scotland College, Edinburgh, where he had as fellow-students a band of men several of whom later gained considerable distinction—Dr. David Patrick, Professor Elmslie, Professor George Adam Smith, and "Ian Maclaren." Among them Drummond at once took a leading place, alike by virtue of intellect, character, and disposition. His studies specially were directed to natural science. When the young student was in his twenty-second year a visit of Messrs. Moody and Sankey, the American evangelists, drew several of the students into the revival movement, and among them Drummond, who quickly became one of the most popular of the speakers who assisted Mr. Moody on the platform. For fifteen months this work took him to many parts of the British islands. Eventually, however, he began to see that permanent work in the ministry required a fuller training, and he returned to college, though strongly urged by Mr. Moody to accompany him to America. At the close of his college life Drummond gained experience as an assistant-minister, and was invited to London to join Dr. Oswald Dykes, but at the age of twenty-six he accepted a Lectureship in Natural Science at the Free Church College in Glasgow, and thenceforward his official work was scientific and academic.

His experience as a science teacher led him to make an attempt, in stray papers, to overcome the supposed divergence between science and religion that was then agitating many minds in the religious world, and these papers were brought together in book form, under the title "Natural Law in the Spiritual World," but only in a casual way, and without great expectations. This was in 1883. At the same time, Drummond was asked by the African Lakes Company to undertake a journey of scientific investigation in the region of Lakes Nyassa and Tanganyika. The mission was successfully fulfilled, and resulted in the publication of a book, "Tropical Africa," that proved a literary and scientific success. But the effect on Drummond himself, hitherto of a most buoyant nature, was serious, and never effaced. His experiences of the cruelties of African life under savagery, of the sacrifices by which missionary labours are carried on, and the undermining of his own health were such that a tinge of sadness was cast over his subsequent years. On his return he declared that he had "been in the atmosphere of death all the time."

A MEETING BETWEEN DESCARTES AND PASCAL
From the painting by Chartran at the Sorbonne, Paris

When he returned from Africa Drummond found that he was a famous man. His "Natural Law," written casually, and

published without much care, had sprung into an immediate and amazing popularity, and he was being bombarded with letters of inquiry, admiration, gratitude, and remonstrance from all parts of the world.

The next step was an appointment as Professor of Theology in Glasgow Free Church College, a position he held for seven years. His influence on students proved to be so remarkable that he was invited to all parts of the world to vivify the religious life of the religious seminaries, and he not only made the acquaintance of the students in almost all parts of Great Britain, but also in Germany, in America, and in Australia.

In 1893 he was invited to Boston to give the annual Lowell Lectures at the Lowell Institute; and for that purpose wrote the series of papers afterwards published as "The Ascent of Man." The interest aroused was intense; and as the lectures were instantly pirated by American publishers in an incomplete form—from condensed reports that had appeared in the English Press—authoritative publication became immediately necessary.

The book sprang at once into as great a popularity as "Natural Law in the Spiritual World." From this time Drummond gradually failed in health, until his death, at Tunbridge Wells, in March, 1897.

Drummond unquestionably was a far more remarkable man than his books completely indicate, although they have held the attention of the scientific as well as the religious world since their publication. Both his chief works were given to the world without careful preparation and revision, the first for lack of opportunity, and the last for lack of time. He himself gave up some of the positions he had tried to assume and make good in the "Natural Law in the Spiritual World," admitting that a continuity of law cannot be traced necessarily from the material to the spiritual. With the "Ascent of Man" the case is different, and the growth of altruism from a mother's love—"the struggle for the life of others," Drummond called it—is developed in a genuinely scientific spirit. That greater work would have been done by this powerful and polished writer had he lived is universally felt.

Drummond's influence on the men he met was even more pronounced than the influence of his books. Everyone trusted and loved him, and, after his death, such was the belief of his closest friends in the purity of his piety and tenderness of his heart, that they confessed to each other they could not refrain from *praying to him.*

EMPEDOCLES

A Scientific Poet and Philosopher

Empedocles was born in Sicily, about 460 B.C., of Greek ancestry. He was a student of chemistry, of disease, and of politics, and made such an impression upon his fellow-citizens in Agrigentum that they wished him to become their king, but he preferred a democratic form of rule.

Like his Latin successor Lucretius, whose views were very similar, Empedocles embodied his philosophy in verse. Earth, air, fire, and water were for him, though not originally with him, the four elements, and he must rank as an evolutionist, believing in a kind of universal rhythm, with a phase of evolution and one of dissolution ever succeeding one another—to use the terms in which Herbert Spencer framed the same idea long ages later. Love and hate, or sympathy and antipathy, played a large part in his theory of things, and he applied them to the atoms which were postulated by his contemporary, Democritus. Something was needed to account for the combination and separation of the atoms, and Empedocles, according to Tyndall, therefore "struck in with the penetrating thought, linked, however, with some wild speculation, that it lay in the very nature of those combinations which were suited to their ends (in other words, in harmony with their environment) to maintain themselves, while unfit combinations, having no proper habitat, must rapidly disappear. Thus more than two thousand years ago the doctrine of the 'survival of the fittest,' which in our day, not on the basis of vague conjecture, but on positive knowledge, has been raised to such extraordinary significance, had received at all events partial enunciation."

EMPEDOCLES

The guess of Empedocles was indeed much nearer the truth than even Tyndall could know in 1874. Radio-activity has since shown us that multitudes of atomic forms are brought into being and disappear, because of their "unfitness" or dynamic instability, while the atoms of the familiar

elements are the structures which survive because of their fitness or dynamic stability.

Unfortunately, very little is known about the life and death of this great thinker. But such tradition or myth as we have, combined with the fragments of his works that are extant, have inspired two famous writers of the nineteenth century. In a brief poem of two stanzas, called "Empedocles," George Meredith protests against the abandonment of life's problem which is involved in the story of Empedocles's suicide by casting himself into the crater of Etna. Reverence, wisdom, and reason are indeed abandoned by the philosopher, "If heels in air the last of him."

Matthew Arnold, in his "Empedocles on Etna," has touched a deeper note, and has given the modern reader the truest insight into this thinker, into whose mouth he puts such stanzas as these—

Fear not! Life still
Leaves human effort scope.
But, since life teems with ill,
Nurse no extravagant hope;
Because thou must not dream, thou need'st not then despair.

EPICTETUS

The Slave who Believed in Stoicism

Epictetus was born at Hieropolis, in Phrygia, about the middle of the first century of our era, and spent his early years as a slave in Rome. While a slave, however, he was allowed to attend certain lectures given in Rome upon the philosophy of the Greek Stoics, to whom he was allied in blood, and the Stoic philosophy appealed greatly to him. In time he was freed, and began to teach philosophy, though, like Socrates, he appears to have written nothing.

EPICURUS

Epictetus, always lame and poor, though now free, was banished from Rome by the unworthy and cruel Emperor Domitian, and settled in Epirus. A later emperor, Antoninus Pius, was to thank the gods, however, that from the fragments of Epictetus he could collect moral guidance enough to conduct life with honour to himself and advantage to his country.

Epictetus is a teacher of ethics, not a maker of cosmologies, but a student of human nature and human duty. His teaching owes much to the Stoics, but in certain particulars—of self-abnegation, humility, kindliness, and contempt for riches—it so closely resembles the primitive teaching of the Christians that some suppose him to have become actually acquainted with their views. In many important respects, however, Epictetus is a Greek, as indeed he was by blood and tradition. Thus, he does not teach that the truth has been revealed or found, but that men must search for it with an open mind, and that the search and the finding will bring them real happiness and peace.

Worldly pleasure was nothing to him, and he taught that even pain was to be regarded as practically non-existent. A few of his aphorisms, recorded and preserved by his pupils, will best show the quality and significance of the teaching of this lame slave, in whom an emperor found a guide of life. "If you would be good, first believe that you are bad." "No one who is a lover of money, a lover of pleasure, or a lover of glory is likewise a lover of mankind, but only he who is a lover of virtue." "At every feast remember that there are two guests to be entertained, the body and the soul; and that what you give the body you presently lose, but that what you give the soul remains for ever." "A wise and good man does nothing for the sake of appearance, but for the sake of having acted well." "It is decent to yield to a law, to a governor, and to a wiser man." "Time delivers fools from grief, and reason wise men." "The mark and condition of a fool is this, that he never expects either benefit or hurt from himself, but from externals. The mark of a wise man is that he expects all hurt and benefit from himself." "Cities are made good habitations by the sentiments of those who live therein; not by wood or stone."

Nothing further seems to be known as to the life and death of Epictetus, but these quotations give us the essential man.

EPICURUS

The Man who Taught that Wise Pleasure is the Chief Good in Life

Epicurus, from whom the Epicurean philosophy was falsely derived, was born in Samos in the year 342 B.C., and lived there until he was eighteen, when he paid

a visit to Athens, and heard some lectures. Soon he began to lecture on his own account, in Mitylene and Lampsacus. When he was about thirty-six years old he settled in Athens, buying a garden, the name of which was to be ever famous. There he taught many pupils, who came to hear him from every quarter of Greece and Asia Minor.

Epicurus was a great teacher, who made his pupils love him, and whose teaching furnished material for the philosophic argument of so great a poet as Lucretius. He had a definite and well thought out doctrine, both as to the nature and structure of the universe, and as to the duties and place of man in the universal scheme. He has been grossly and quite inexcusably maligned in after days, so that those who are not acquainted with his teaching at first hand have habitually quoted him as the type and champion of sensual men.

Because Epicurus taught that pleasure is the chief good in life, his traducers have assumed that he meant sensual pleasure, of the palate—whence our word, epicure—and the flesh; and they have thus misled even so great a classical scholar as Milton into speaking of the "Epicurean sty." The judicious observer may well question this version of Epicureanism, reflecting that it furnishes an insufficient explanation for the immense fame and contemporary homage paid to this thinker, or even for the fact that his name is remembered at all, the preachers and practitioners of sensuality being scarcely unique in any age. It is therefore worth while to know what Epicurus really taught, and what manner of life was led in his garden.

Pleasure, said Epicurus, is the legitimate end of life. This was the necessary and inevitable protest against the extreme of Stoicism, which taught the renunciation of all desire, the suppression of the Self, and the abandonment of any belief in the natural harmony of things. Nature is not so diabolically made, according to Epicurus, that the wise man has no choice but stoicism. On the contrary, he may rightly aim at pleasure, for himself and for others; "but when we say that pleasure is the end of life we do not mean the pleasure of the debauchee or the sensualist, as some from ignorance or from malignity represent, but freedom of the body from pain, and of the soul from anxiety."

On further inquiry we find that in the innocent garden of the Epicureans, which was afterwards to be represented as a pigsty, life was lived upon the simplest and most unsensuous principles. Here is the inscription which ran over the entrance to the garden of Epicurus: "The hospitable keeper of this mansion, where you will find pleasure the highest good, will present you liberally with barley cakes and water fresh from the spring. The garden will not provoke your appetite by artificial dainties, but satisfy it with natural supplies. Will you not be well entertained?"

Yet those who would teach the true Epicureanism today, when it is so badly needed, are met with such epithets as "Puritan kill-joys"!

Though Epicurus was deeply interested in cosmological speculations, philosophy for him was not what it meant for Plato and Aristotle. For them philosophy was the quest for and discovery of Truth. The whole Truth will, indeed, include the wisdom of practical life, but Epicurus was more explicitly practical in his views. The real worth and function of philosophy was for life, he said. "Philosophy is that power by which reason conducts men to happiness." He wished all men to enjoy that true pleasure or happiness which has its twofold base in health of the body and peace in the soul; he studied philosophy, and taught it, to this end; and in his garden he and his friends practised what they preached.

The "man in the street," as we now call him, wishes happiness also, but Epicurus declared that the plain man needs philosophy to help him. "Every pleasure is in itself good, but, in comparison with another, it may become an evil. The philosopher differs from the common man in this—that, while they both seek pleasure, the former knows how to forgo certain enjoyments which will cause pain and vexation thereafter, whereas the common man seeks only to enjoy. . . . Happiness, then, is not the enjoyment of the moment, but the enjoyment of the whole life. . . . No life can be pleasant but a virtuous life; and the pleasures of the body, though not to be despised, are insignificant when compared with those of the soul. The former are but momentary, the latter embrace both the past and the future."

Surely this man is the very master of those who teach the true art of life. Temperance he taught in all things. The soul was to be honoured above the body, yet the body was not to be despised. All powers of enjoyment were to be cultivated, yet the wise man was to be able at any time to do without them.

At the same time, it was necessary to know something of the external world, and here Epicurus taught, very closely, those doctrines of Democritus with which he had first made acquaintance when he visited Athens in his youth. His scheme of the world was definitely mechanical and materialistic, as we see in the poem of his follower Lucretius. He believed that the soul perishes with the body; but, nevertheless, he daily and urgently opposed the doctrine "Let us eat and drink, for tomorrow we die." All of his extremely copious writings are lost. In his latter years his health became impaired, but he never lost the serenity and cheerfulness which earned for him so much love. He died in the year 270 B.C., having shortly before passed the "allotted span."

RUDOLF EUCKEN

A Harmoniser of Philosophy and Religion

Within the last few years students of philosophy, and especially such of them as are interested in religion, have given exceptional attention to the works of Professor Eucken, of Jena, whose writings are now becoming available for English readers. What has drawn many to Eucken is the note in his writings of optimism based on a tangible faith.

Rudolf Eucken was born at Aurich, in East Friesland, Germany, on January 5, 1846, and was educated at Göttingen and Berlin. In 1871 he became Professor of Philosophy at Basle, and in 1874 at Jena, where the rest of his life has been passed with much gain in popularity to that famous university.

Eucken began his literary work with studies of the historical philosophies, studies that can be followed in part through his book "Problems of Human Life." Later he developed his own philosophy in "Life's Basis and Life's Ideal," and his view of religion in "The Truth of Religion." There is no writer of the present day—not even Bergson—who is being more eagerly discussed and keenly criticised. The general effect of his influence is to impress men with the reality of the spiritual life. It is the problem of life that Eucken attempts to solve, not as a curiosity but to provide a basis of belief and an inspiration. He is in dead earnest, and never argues round a point, led on by the mere obsession of argument, but goes straight towards what he regards as essential truth. He discusses the nature and purpose of life in two broad, contrasted divisions—namely, as a spiritual force, and as it appears to those who only try to make the best of this world. His appeal is on behalf of the "overworld," or supernatural world, as against the world of the senses.

He considers that, in this conflict, religion —Christianity, as generally understood— fails to give faith sufficient hold. It has surrendered too much to the influence of "the world." It thinks too much of prosperity and material progress, and too little of ideals. It needs to be lifted to a higher plane of idealism. A study of Nature merely will not give the necessary idealism. Socialistic culture and individualistic culture are alike impotent to lead us to a true appreciation of the best in life. We must "see life steadily, and see it whole," in its relation to the universe. Eucken is specially interesting as having his own theory of life.

He holds that the deepest realities of life are reached and apprehended by action, rather than by thought. Running through life, and forming it for ever, is the eternal truth of a deeper world than this material world of ours, as we may find alike by the study of history and of the present—an influence independent of time, and universal, a fount of spiritual life, a "something higher" towards which there is a perpetual aspiration; and only as we "live into" it can we transcend the material, and truly live. Beginning with the reality of this universal spiritual life, Eucken contends for its inherent dominance over both the material and intellectual spheres. It finds expression in a "higher life," through man, who is the point of union between the natural and the spiritual worlds.

Eucken traces the growth of the struggling impulses of man towards this higher life of the spirit, until he reaches the freedom and certitude of the spiritual, and is at one with the Universal Life. Such spirituality lives unquenchable, and in it the human may be made divine by the power of the Godhead, while the natural, or material, dies. True religion is the appropriation of the divine by the human, in act and life, not in belief. This spirituality has to be retained by constant activity in following the highest.

Eucken agrees that Christianity, though only in many respects the temporary colouring of essential religion, and not a full expression of eternal truth, far surpasses all religions, and, indeed, may be so modified as to become the Absolute Religion.

His aim obviously is to raise philosophy from the realm of wordy theory into an

inspiration towards noble living. Although not ostensibly written in defence of Christianity, Eucken's philosophical writings are, in effect, likely to be perhaps the most powerful influence of the present day in giving thoughtful readers a sense of "a sure pathway to that eternal truth which all the changes of time cannot destroy."

EUCLID
The Man who Taught Mankind Exactness in Reasoning

Euclid, whose "Elements" have permeated the scientific thought of more than twenty-two centuries, is himself a dim

EUCLID

figure in the long procession of Greek thinkers. Very little is known of his personal or family history, but from statements made by the philosopher Proclus (412-485 A.D.), in his commentary on the first book of the "Elements," it is probable that by the year 300 B.C. Euclid's fame as a mathematician was fully recognised.

He lived in the reign of Ptolemy I., King of Egypt, and is said to have numbered that monarch amongst his pupils. Encouraged by so enlightened a ruler, it is not difficult to believe that Euclid founded the celebrated geometrical school of Alexandria. The city at that period was the magnificent home and centre of science, and Euclid's new mathematical university a focus for zealous students from all the civilised East.

But Euclid was not the father of geometry; he was heir to the scientific legacies of Thales and Pythagoras. The former is universally acknowledged to be the founder of Greek geometry, and to have given the initial impulse to that love of science which ever after distinguished the Hellenes.

One of the most important and practically useful propositions in Euclid—Book I., 47—is ascribed to Pythagoras, who died 500 B.C., and of whom an old writer declared that he "changed geometry into the form of a liberal science, regarding its principles in a purely abstract manner, and investigated its theorems from the immaterial and intellectual point of view."

A century later appeared Plato, at a time when science had emerged from its infancy. Tradition tells that the words, "Let no one ignorant of geometry enter here," were inscribed over the door of his school. But in this special field of reasoning the harvest gathered by Euclid was necessarily richer than that of his illustrious predecessors. He was able to examine their discoveries, and the solutions of mathematical problems attributed to them; "to reduce to invincible demonstration many things that had previously been more loosely proved," and to add enormous contributions of his own to geometry.

So great has been the homage paid to the genius of Euclid—or so slowly has the mathematical faculty of mankind developed—that until the seventeenth century his methods stood unchallenged, unimproved, and unenlarged. The effect of his labours, not only upon the whole world of science but on the life and pleasures of men through the channels of art, is altogether incalculable. He has not only provided means of disciplining the intellect, but has supplied facts and conclusions which tell directly upon architecture, manufactures, and every mechanical enterprise in existence.

Other works of Euclid are the "Data," of which Robert Simson, his modern editor, says it is "the first in order of the books written by the ancient geometers to facilitate and promote the method of resolution or analysis"; and the "Phœnomena," bearing on astronomical science.

Euclid has been credited with several other writings about the genuineness of which commentators are not agreed. These include the "Introduction to Harmony," the "Section of the Scale," "Optics," "Catoptrics," and the "Division of Superficies." But it is upon the indubitable merits of his "Elements" that the reputation of Euclid of Alexandria will rest.

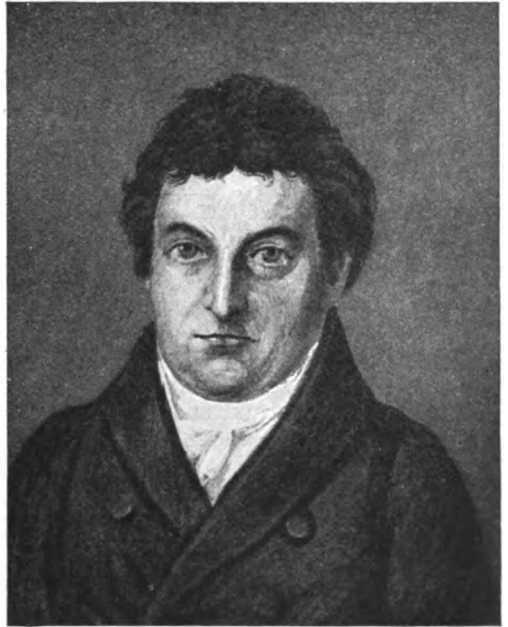
Even till a comparatively recent time tyros in science thought the word Euclid was the synonym of geometry. Euclid and algebra, not geometry and algebra, were bracketed together as subjects of the school curriculum. Modern criticism has sharply questioned the adaptability of the "Elements" as a course for beginners, on the ground of defective classification, redundancy, and other blemishes. The textbook has almost disappeared from schools in America and on the Continent of Europe, though it is still used very widely in Great Britain. But in English schools algebra has now become the handmaid of geometry, so making the processes of reasoning more easily and rapidly grasped than they would be by the more involved, if often elegant, demonstrations of Euclid. The "Elements" have been translated into many languages, but the only edition which contains all the works attributed to Euclid is published in English.

JOHANN GOTTLIEB FICHTE

A Believer in Mastery Through Education

Johann Gottlieb Fichte was born in Lusatia on May 19, 1762, and studied at the University of Jena, thereafter visiting other schools of learning, and enjoying, in 1791, the immense privilege of converse with Immanuel Kant. In the following year he published his first book, which gained for him, in 1794, the Chair of Philosophy at Jena.

Fichte was an idealist, a man whose chief business in life was to show how God transcends our ideas of Him. It was therefore natural that, in 1799, he should be accused of atheism and, in consequence, should lose his Chair, and migrate from Jena to Berlin, where he taught privately. Those were the days of the Napoleonic terror, and Fichte proved himself a true patriot and great German in his "Addresses to the German Nation," wherein he declared that national prosperity and health and security must be based upon a system of public education.

The year 1809 was that of Prussia's greatest misery. We may recall such tragic names as Jena, Auerstadt, and Wagram. A crushing war-tax hung over the country, and the necessaries of life were at famine prices. Everyone, from the King to his meanest subject, was compelled to make sacrifices and practise rigid economies. In this year, thanks to the natural qualities of the German people, and, above all, to the splendid pleadings of Fichte, the Government voted a large annual sum for the foundation of the University of Berlin. This, says Dr. Merz, was "an act as heroic as the great deeds on the battlefield, and as far-seeing as the measures of Stein and Scharnhorst." Faced by the most terrible enemy the world had ever known, a man unbeaten and insatiable, the Prussians founded a

JOHANN GOTTLIEB FICHTE

school of learning. Even if, a century afterwards, we had not a long debt of gratitude to pay for the knowledge which that school has gained for mankind, the foundation of the University of Berlin would remain a lesson, a monument, a noble warning, and example to patriots of all ages.

Fichte was, of course, made Rector of the new University, which was opened in 1810. Three years later, his wife, nursing in war time, caught and recovered from a fever, which her husband, who nursed her, caught. The attack proved fatal to him, on January 27, 1814.

Fichte has been popularly represented in English-speaking countries by Thomas

Carlyle, who adopted his Divine Idea of the Universe. He saw the universe as consisting of the *Ego* or I, and *Non-ego*, or that which is not I, myself. Theoretical or metaphysical science is that which concerns itself with the ego ; practical science, with the non-ego, or material world ; but it is only through our consciousness of the ego that the material world exists. The absolute Ego is God, who becomes manifest through all existence, which is the vesture by which the divine and infinite makes itself apparent. The whole universe is thus the visible embodiment of the divine ideas and being, and Nature the manifestation of God, the animating spirit of all things. Thus, the ascent of man, as now understood, would be an unfolding manifestation of the Godhead. Fichte, always a man of purest life, grew more religious the longer he lived. His philosophy of " transcendental realism " is not expressed in the language of today, but, in essence, is still widely accepted. Fichte's thought, though often nebulous, has had an ennobling influence ; and his practical work finds splendid expression in the University of Berlin, which he founded firmly in the midst of national turmoil.

BENJAMIN FRANKLIN
The First All-Round American

Benjamin Franklin, the first many-sided American who made a great impression on the civilised world, and one of the earliest to be interested in science, was born at Boston, Massachusetts, on January 17, 1706, the tenth son in a family of seventeen children. His father, who was a tallow-chandler and soap-maker, had an idea of dedicating him to the ministry, as the tenth son, but Benjamin had little chance of preparing for such a career. After two years at school, he was kept busy in the chandlery until his apprenticeship as a printer, at the age of twelve, to his brother James. There could not have been a better trade for such a lad, ingenious, resolute, and seething with mental activity. Soon he was the best printer in the office of the " New England Courant," and, while still working at his " case," attracted attention by his original contributions. When James Franklin found himself—as the custom was in those days—in prison for writing what he thought, the apprentice Benjamin conducted the paper quite successfully, and for that purpose was released from his indentures.

After that it was not likely that he would fall again in the routine of a journeyman printer, and following his brother's release they parted, and Benjamin went to Philadelphia. There he soon became the manager of a newspaper and printing business, and began to form schemes for starting an up-to-date newspaper of his own. As a step he was persuaded by the English governor to visit England to gain experience and buy types, and, relying on the governor's help—which utterly failed him—he crossed the seas and spent eighteen months in the Motherland, where his skill as a printer at once secured him employment. On his return to Philadelphia, Franklin established his newspaper, and scored not only an immediate but a permanent success. He was a born journalist, whether regarded as a writer or business manager.

His great success in this part of his life, so far as the outside world was concerned, centred on his " Poor Richard's Almanack," which, in addition to the usual advance information, was made a repository of proverbs and sententious sayings that suited particularly an age of thrift. Franklin sold regularly about ten thousand copies of the almanack, and it was not only translated into almost every language in Europe, because of its practical fireside wisdom, but has been a mine whence almanack sayings have been brought for the last 180 years.

Having become the most conspicuous figure in the little newspaper world of the Colonies, Franklin naturally entered public life. Such a man was wanted. When, at the age of thirty, he became clerk to the Pennsylvania Assembly, he had overcome the early disadvantages of his education, and was a well-read, intellectual man with wide interests, but also with a singularly practical turn of mind.

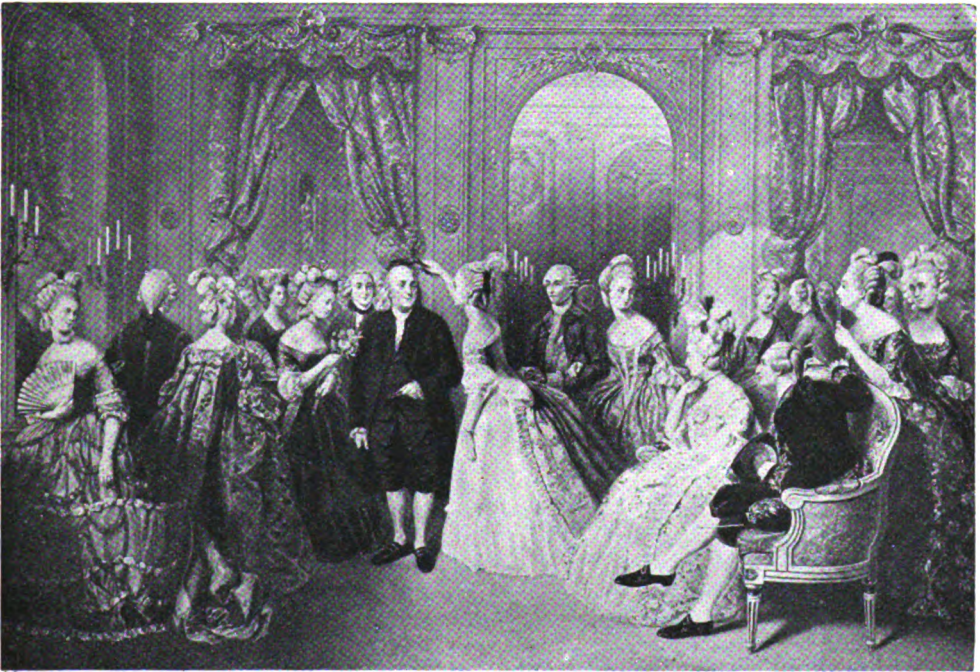
His " Autobiography," written in a large degree during old age, is one of the most interesting books in any language, telling how the character of a distinguished man was built up—not without lapses—and the foundation of a genuine education laid wide and deep. From 1736 onward Franklin took an active part in public life. He became postmaster of Philadelphia, and eventually deputy postmaster for the whole of the Colonies.

In 1746 he began to make the scientific researches, particularly into electricity, which entitle him to a honourable place in the story of the progress of science. He proved that lightning and electricity are the same thing, and so far came to understand their action as to suggest the protection of buildings by lightning conductors. He made a special study of meteorology,

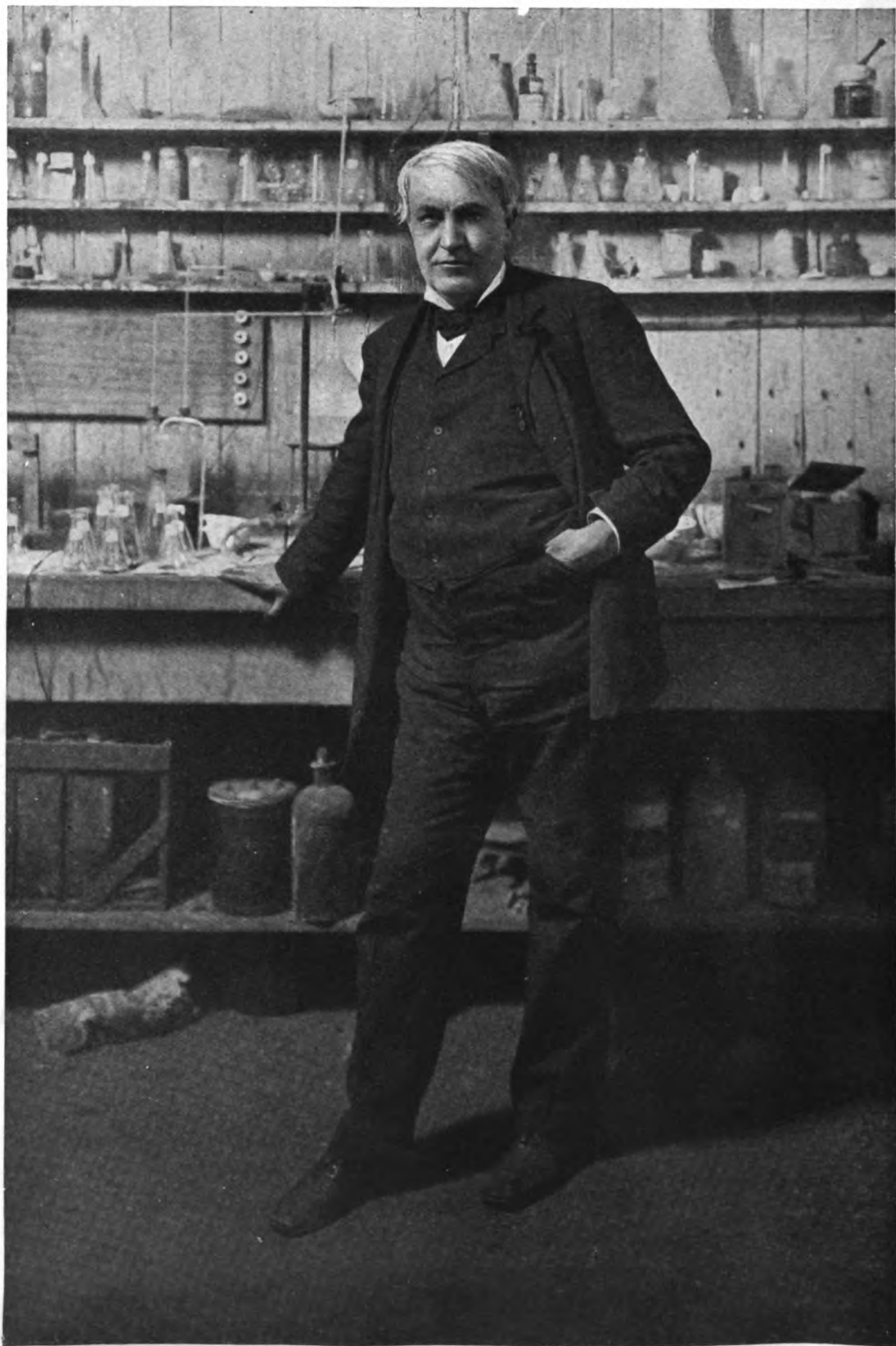
with a view to forecasting the weather; studied the Gulf Stream, its temperatures and effects; and showed the heat-retaining powers of different colours. His position in the scientific world, in short, became of such importance and interest that, when he was sent, in 1757, to England, on a diplomatic mission, he was recognised as a scientist of world-wide distinction, and was given a doctor's degree both by Oxford and St. Andrew's Universities.

Franklin was highly successful as a diplomatist, and remained in that capacity five years in England. Two years after his return to the States he was again sent over to negotiate a settlement of the differences which finally led to civil war, and the loss of the American Colonies. During these negotiations he was regarded as leaning unduly to the side of the Mother Country, but when all his efforts proved useless, and war began, he cast his lot unhesitatingly on the side of resistance against tyranny.

As the war progressed, Franklin was sent to France as special commissioner representing the revolting States, and to arrange for French help; and he negotiated an alliance between France and the States. Franklin remained in Paris until he was in his eightieth year, when, by leave, he retired; but on reaching home was chosen President of Pennsylvania, and held the office for three years. In 1788 he retired from public life, and died on April 17, 1790, whereupon the Congress of the fourteen federated States, which had now won their independence, ordered mourning to be worn for him for a month, and the French Assembly ordered it to be worn for three days.

Franklin attributed his success to diligence in business. This, he said, had caused him to stand before five kings; but it was not only the diligence that led him while still in a distant land to fit himself for the most delicate diplomatic work—as, for example, obtaining a fluent command of French—that accounted for his success, but great mental acuteness, a shrewd knowledge of character, and a personal charm which made admiring friends wherever he went. Franklin's great reputation in later life indeed was personal in a large degree, for he wrote little, and what he did write had lost the strength of his earlier style.

BENJAMIN FRANKLIN AS AMERICAN AMBASSADOR AT THE COURT OF FRANCE

There can be no doubt that if Benjamin Franklin had followed the leading of his spontaneous inclination he would have been a scientific investigator during the last half of his long life. As it was he was only a very distinguished amateur engaged in experiments in the intervals of a busy life. Yet he was a member of the Royal Society at the age of forty; and in America he may be said to have founded experimental science.

MODERN MAN'S MOST INVENTIVE MIND

THOMAS EDISON IN HIS LABORATORY IN A STUDIOUS MOOD

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INVENTORS

JOHN BOYD DUNLOP

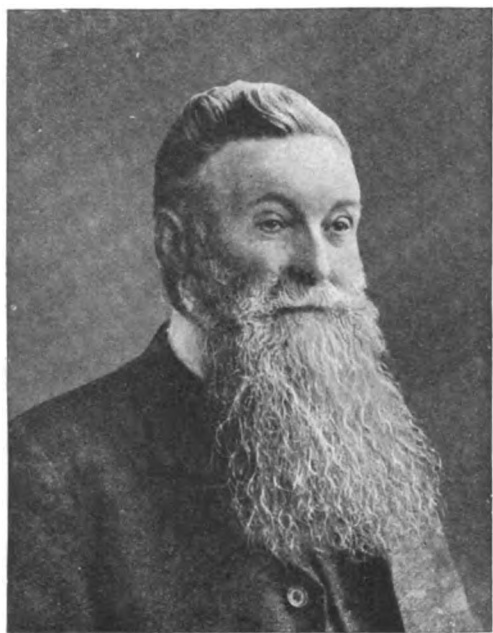
The Re-Inventor of the Pneumatic Tyre

JOHN BOYD DUNLOP was born at Dreghorn, Ayrshire, in 1840, but was early established in Ireland, where he gained considerable reputation as a veterinary surgeon. It is singular that the man who, more than any other, was to reduce the dependence of his fellows upon the labour of the horse should, until long past his youth, be engaged in promoting the science of breeding and maintaining that animal. But his thoughts turned to other methods of conveyance upon the roads than horse-power, and the only obvious alternative was the bicycle or tricycle, shod in his youth with iron, and later with solid tyres of rubber. He conducted many experiments with a view to bettering this plan, and only those who cycled before the creation of the pneumatic tyre can have any conception of the improvement that he managed to effect for the comfort and speed of the rider.

The thanks and praise of his generation are due to Mr. Dunlop for the labour undertaken by him to bring his invention to perfection, but the strange thing is that he had been anticipated by forty-three years. The pneumatic tyre was really invented and patented when Mr. Dunlop was in petticoats. Its inventor was Robert William Thomson (1822-1873), a Scottish engineer, whose brain was a magazine of original ideas. But he was more than a generation too early. There were two reasons which inevitably rendered his invention of 1845 still-born. Indiarubber was a costly luxury, a wild product then won with difficulty from the virgin forest; and had it been plentiful and cheap there could not yet have been any demand for it.

When he began his experiments in the 'eighties, Dunlop seems to have known nothing of Thomson's patent. He began de novo, created afresh, and in fairness it must be said that he created better. He himself did not realise the importance of his own work. He fashioned a cushion of air for the cyclist, and in so doing made the motor-car possible. Thomson fitted rubber tyres to a remarkable engine specially devised for hauling sugar-cane in Jamaica, where he was employed, but that was in no way related to the modern pneumatic tyre which carries a seventy or eighty horse-power motor-car. Thomson's pneumatic tyre was a brilliant idea, not a practical marketable commodity; it was the germ of a marvel falling on stony ground. Dunlop worked entirely independently of that invention, and it is unlikely that we should ever have heard again of Thomson's work had not Dunlop's invention brought it back to mind.

Without Dunlop there would have been no motor-cars on our roads today, for we could not have had high-speed engines on wheels shod with solid rubber. The motor-'bus and the motor-lorry remind us what travel with the solid tyre would have meant, though with smaller cars of lighter frames the shocks and vibration would, of course, have been infinitely worse, and the speed contemptible. Dunlop's tyre, patented in 1888, marked a new epoch. It added new limbs, as it were, to civilisation. It created two enormous new industries, the cycle trade and the motor industry, enterprises in which colossal sums have since been invested. Its effects may be traced in a couple of concrete instances—that of Coventry, whose population has nearly doubled within recent years; and that of Stuttgart, where the manufacture of motor-cars has brought a new town into existence under the walls of the old city.

It has been said that since primitive man first adopted the wheel, and so opened up a new era in transport, no invention of greater importance to travelling man has been achieved than the rediscovery of the pneumatic tyre by Mr. Dunlop. It is gratifying to remember that when it was proposed a little while ago to erect a statue to Mr. Dunlop, a body of men, faithful to the memory of the unrewarded Thomson, suggested that a statue should be erected in his honour also.

JOHN DUNLOP

THOMAS ALVA EDISON

The Greatest Inventor of All Time

Thomas Alva Edison was born at Milan, Ohio, on February 11, 1847. The son of humble parents, he received but scanty schooling, and at twelve years of age was engaged as newspaper-seller on a railway train, in the baggage-van of which he established a miniature laboratory, and began his chemical experiments. The American Civil War being in progress, he collected intelligence at large stations, printed it with his own type and press, and sold his papers—the first ever published from a railway train—both to passengers and to people waiting at the smaller railway-stations to hear the latest news. A fire in his little laboratory caused him to be expelled from the train, but a kindly station-master, whose child Edison saved from death, taught him the elements of electric telegraphy. The youthful inventor turned his knowledge to account by fitting up primitive telegraph instruments and a wire, run along a fence, so connecting the station with the town near by, and conducting a telegraph service at a shilling a message.

While engaged as a railway telegraphist he invented an ingenious mechanism which automatically transmitted a telegraphic signal. It was an idle boy's labour-saver, but it proved of considerable importance in telegraphy, and was the precursor of a host of other devices of increasing value.

He was still occupying a menial position on the railway when he discovered that as a telegraph wire will carry simultaneously two currents of different intensity, two messages may be sent at once over the same line. This led to his invention of duplex telegraphy, followed by his quadruple and sextuple systems. It is estimated that these inventions have saved the American telegraph companies four millions sterling in the cost of wire alone.

He was only twenty-seven when he perfected his printing telegraph for Stock Exchange quotations, an invention which was the advance guard of a large number of similar schemes, and brought him at once eight thousand pounds. This enabled him to become an employer, and to give full rein to his inexhaustible capacity for bringing new ideas into practice.

A marked change now came over his life. Up to this point the man whose discoveries were changing the character of business methods in America and Europe had been, from the time of his quitting the service of the railway companies, little better than a tramp—at best an inspired vagabond. His mind teeming with great schemes, he had wandered from pillar to post, earning a little money here, spending it there in books or chemicals, and dissipating the savings of half a year on some long-planned experiment which would have delighted the heart of the most hardened alchemist. The practical nature of Edison's genius enabled him not merely to initiate schemes of his own, but to modify the faulty schemes of less practical men.

His name is inalienably associated with the development of the telephone, and this is due to the fact that he detected the weakness of the Bell transmitter. Edison has a way of converting unpromising materials to his use, and here he employed lampblack as a principal constituent, finding that by this means far better results were obtainable before. The original Bell

transmitter, with various modifications, has become the receiver, and Edison's the transmitter. Edison was offered an immediate £20,000 for his invention. But he had learned wisdom; he knew that if such a sum came suddenly to his hand he would swiftly dissipate it in tempting experiments. "Pay me £1200 a year for seventeen years," he said; and so for the first time had an assured income for a term of years.

A period fruitful in inventions followed, such as the microphone, which so increases sound as to render audible the footfall of a fly; the microtasimeter, which records minute variations in temperature and registers the heat of a star upon the earth. And so, every new idea opening out some fresh horizon, he was led gradually to the evolution of the phonograph. The first machine consisted of a cylinder covered with detachable tinfoil—a diaphragm and trumpet. The words spoken through the trumpet and diaphragm created certain indentations upon the tinfoil which clothed the revolving cylinder; and there came a day when the instrument gave him back the line "Mary had a little lamb," the first words ever delivered by the talking machine. All the numerous family of sound-producing instruments are the descendants of the primitive machine which repeated the nursery rhyme after its creator.

Next, taking up the idea of moving pictures to reproduce to the eye the sugges-

THE WHEEL WITH THE FIRST DUNLOP TYRE

tion of form and mobility, he produced, in the kinetoscope, the parent form of the cinematograph and similar wonders; and latterly he has adapted his phonograph to work in conjunction with his moving pictures, so that not only the outlines of figures in movement, but their voices, may live again ten thousand miles away. Both these inventions, at first scientific toys, have since become important items of

THE BIRTHPLACE OF THOMAS EDISON

practical utility, the former in business, the cinematograph in education and science.

The high vacua secured by the Crookes tube prepared the way for the Edison incandescent lamp. Edison took up electric lighting when the only means of electric illumination was the arc-lamp, which was impossible for ordinary indoor purposes. He organised a literally world-wide search, extending over some years, for a suitable filament for his lamps, and at last found it in the inner bark of a Japanese bamboo; and for a decade this vegetable growth, carbonised and chemically treated, served to light the lamps of a thousand centres. Metallic filaments have now replaced the fabrics that followed Edison's first attempts.

Two great industrial schemes next engaged his attention. In the first he devised a plan for detecting small quantities of iron ore in rock, and then of crushing the rock and of separating the metal from its matrix by means of powerful magnets. He installed a great plant for carrying out the work, only to see abundant cheap rival ore discovered near his works which made it impossible for him profitably to work his plant. He closed down his works, a heavy loser; but the day will come, no doubt, when the scheme will be gladly revived to work poor deposits in localities where richer yields cannot be found. Proceeding from this failure to another success, he devised a method of cheaply and swiftly building

houses and other premises, by means of concrete poured into huge metal moulds, which, as the concrete hardens, can be withdrawn, leaving the walls and floors of a building complete in a few days from the installation of the foundations.

Since then he has made many attempts to provide the long-sought electric storage battery which shall make the electric motor-car capable of running long distances, and, at the same time, enable the consumer of electric current to depart in safety from the neighbourhood of the dynamo to which his batteries have now frequently to be sent to be recharged. He has improved the battery, but has not yet, in spite of repeated announcements to the contrary, found the great secret which will make such battery the long-service repository that we all seek. The list of the Edison inventions in practical electricity runs into many hundreds, and only the most notable have been mentioned.

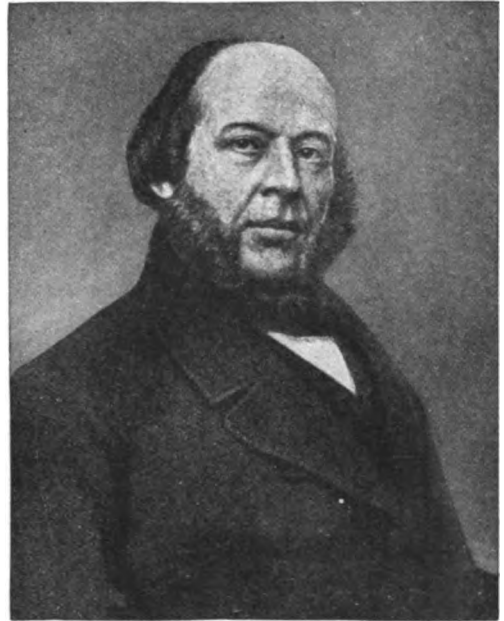
His inventions are embodied in our electric trains, our trams, in our telegraphs, our telephones, in our lighting, in our entertainments, in our schools and universities, and in hospital practice, in the home, the factory, and the street.

What Lister did for surgery, what Burbank is doing for botany, what Berthelot did for synthetic chemistry, Edison has done for electricity in its application to the needs of our daily life. Few men have so profoundly influenced the science and industry of their day as has this American product of Scotch and Dutch blood. He himself has acquired riches, but the commercial worth of his inventions to the world is incalculable.

JOHN ERICSSON
The Maker of the First Workable Screw-Propeller

John Ericsson was born at Langbanshyttan, Vermland, Sweden, on January 31, 1802, the son of an inspector of mines. After diligently studying the machinery of mines near his home, he designed, when ten years of age, a pump for draining mines of water, the pump to be driven by a windmill, which he planned from a verbal description of one already in existence elsewhere. At twelve years of age the boy, who was "the wonder of the district," was engaged as a draughtsman by the Swedish Canal Company. Entering the Swedish Army as a private, when seventeen, he was speedily marked for his unusual proficiency in drawing and map-making, and was advanced to the rank of captain. He was still a Swedish officer on furlough when, hearing of the engineering feats of Englishmen, he visited England and associated himself with John Braithwaite, the engineer.

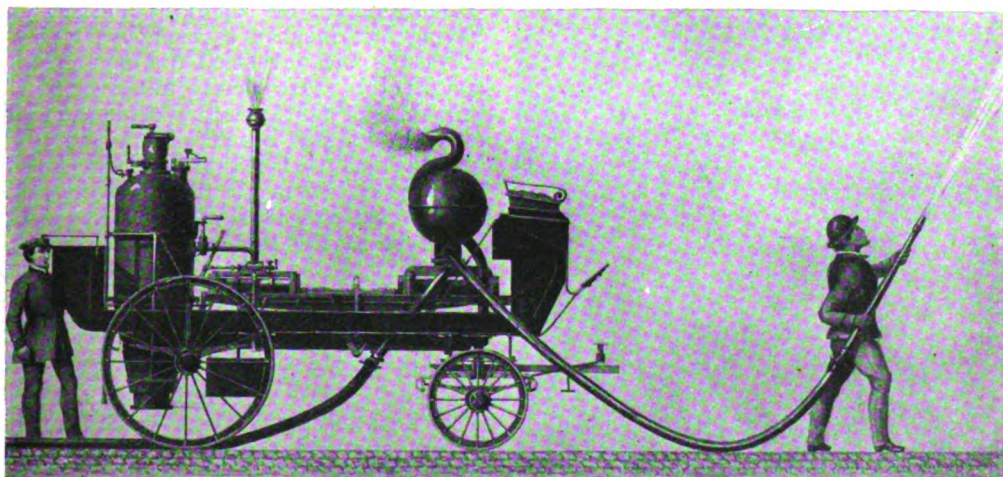
Quitting the army in 1827, he settled for a time in England, and entered for the steam locomotive contest, the prize for which was to be £500 and the glory of putting on to the first steam railway the first steam locomotive. He had already effected certain notable improvements in marine engines. The ship which carried Sir John Ross to the Arctic regions in 1829 contained engines built on the Ericsson plan.

He quite expected to beat Stephenson in the contest for the locomotive prize. But Stephenson and his son had been living with and for their idea; Ericsson

JOHN ERICSSON

came relatively late to it. He is said to have built his engine in six weeks. The two Stephensons alone knew the capacity of their little "Rocket." The engine built by Ericsson and Braithwaite was the "Novelty." It weighed only 3 tons 1 cwt.—24 cwt. less than the "Rocket." Before the trial, Ericsson's engine was first favourite, and at its initial spin it ran, at times, at twenty-four miles an hour, in place of the ten miles demanded by the conditions. But it was less carefully thought out than its English rival. The English engine had the steam-blast; Ericsson's had air forced by bellows through the fire, and these bellows, together with burst steam-pipes, were its undoing. The "Rocket" proved

incomparably the better engine, and, when the prize had already been won, travelled at the rate of thirty-five miles an hour—a speed which even today must make certain suburban railway companies almost hold their breath. Ericsson did no more with steam locomotives, but turned his attention to the propulsion of ships, and perfected the screw propeller. The idea did not originate with him, for the propeller has a history of its own; but when at last the Admiralty, after swearing they would ne'er consent to its use, consented, Ericsson, after heartbreaking rebuffs and delays, was awarded £4000 as his share of the £20,000 awarded by the Admiralty in payment for the idea.

Ericsson was far ahead of his time in England, and his ill success with a steam fire-engine, coupled with his experiences over the screw propeller, drove him from the land. His experiences in the United States, whither he now transported himself, were at first little happier. Professional conservatism was not then the monopoly of any one nation, any more than enterprise and initiative are today. Although his fame had preceded him as the designer of the first boat driven by screw propeller across the Atlantic, he had infinite opposition to meet. The Civil War yielded him his great chance, when the armouring of the Confederate steamship "Merrimac" brought Ericsson to grips with a subject which he had made his own.

He furnished the Federals with their reply. It was the redoubtable "Monitor." Designed to follow the enemy into shallow water, her draught was limited to a depth of eleven feet. It was thus impossible to carry the armour necessary for a high-built ship. Ericsson constructed one with sunken hull, crowned with a cylindrical armoured turret, which carried the gun and the gunners, and, as it revolved on its vertical axis, delivered an all-round fire while the vessel was stationary. The success of the vessel was immediately established by her battle with and defeat of the "Merrimac." The ironclad and the armoured turret had come to stay, and a revolution in naval architecture began. Though mainly concerned with shipbuilding in his later life, Ericsson covered nearly the whole field of mechanical invention. He died in New York on March 8, 1889, and his body was carried by an American warship to the land of his birth.

THE FIRST STEAM FIRE-ENGINE MADE BY ERICSSON AND BRAITHWAITE IN 1830

GABRIEL DANIEL FAHRENHEIT

The Maker of a Famous Thermometer

Gabriel Daniel Fahrenheit was born at Danzig, Prussia, on May 14, 1686. He was intended by his parents for a commercial career, but was fortunately able to avoid the counter and the office, and devote himself to natural philosophy. In pursuit of his studies he travelled through Germany, Holland, and England, and lived for the most part in the two last-named countries. It is quite erroneous, of course, to speak of him as the originator of the thermometer. What he did was to break away from the old practice of charging the tube with spirits of wine or alcohol, and to substitute mercury.

This has many advantages over other fluids, and some of its qualities are unique. The scale now in use is not exactly that

which he fixed, but is near enough to be recognisable. He established his scale in the following manner. Zero he fixed as the lowest temperature that he observed during the winter of 1709 at Danzig; the space between this point and that to which the mercury rose at the temperature of boiling water he divided into 212 parts or degrees. He gave the 32 degrees as freezing-point, in order to avoid negative figures—which in the later centigrade scale so often proves a stumbling-block to the uninitiated. Fahrenheit, who was elected a Fellow of the Royal Society, made several contributions of value to the scientific publications of the period, and

ROBERT FULTON

devised an improved hygrometer. He died in Holland on September 16, 1736.

JEAN BERNARD LEON FOUCAULT

The Measurer of the Speed of Light

Jean Bernard Léon Foucault was born in Paris on September 18, 1819. Galileo, in the 'thirties of the seventeenth century, braved the terrors of the Inquisition when he declared that the earth moves; Foucault gained immense fame in 1851 by *proving* it. The French physicist suspended a pendulum to the lofty roof of the Pantheon, the point of suspension being vertically over the centre of a round table. It was then seen, by the slow but certain apparent movement of the table in a contrary direction to the hands of a clock, that the earth rotates, carrying with it, of course, the table and the building containing it, but leaving the pendulum still oscillating in space in the same plane.

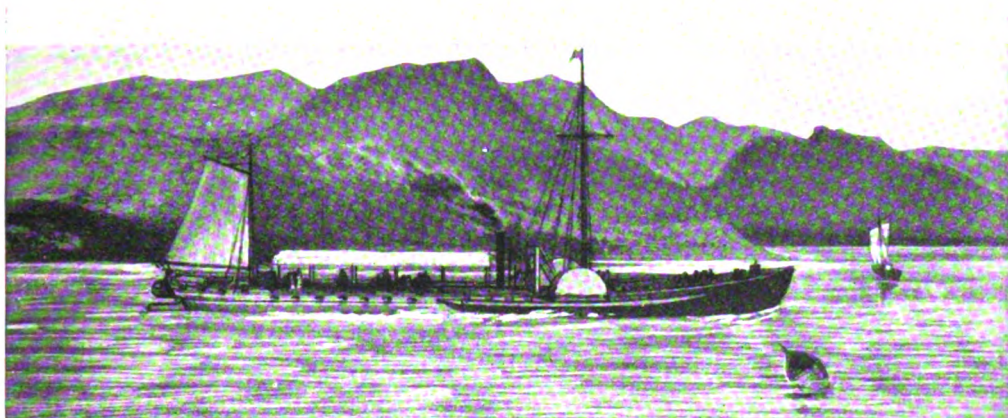
In the following year Foucault invented, or it would be better to say adapted and improved, the gyroscope, for the gyroscope was known in principle for perhaps a century before his birth. With his gyroscope Foucault repeated his experiment, and confirmed the results already obtained. Since then his gyroscope has become part of an implement of war, in the Brennan torpedo, and promises to be of more service in peaceful occupations employed to preserve the stability of mono-rail trains, and to the roll of ships in stormy seas.

Foucault was the son of a publisher, and, having first inclined to medicine, took up chemistry and developed the daguerrotype considerably. He closely investigated the properties of light, a natural sequence to his experiments on behalf of photography, and revealed the fact that light travels with greater velocity in air than in water, and that in different media the velocity varies inversely as the refractive indices of the respective media. Appointed physical assistant in the Paris Observatory, he soon afterwards discovered what are known as the Foucault currents—*i.e.*, electric currents induced in a mass of metal when in a magnetic field of varying intensity.

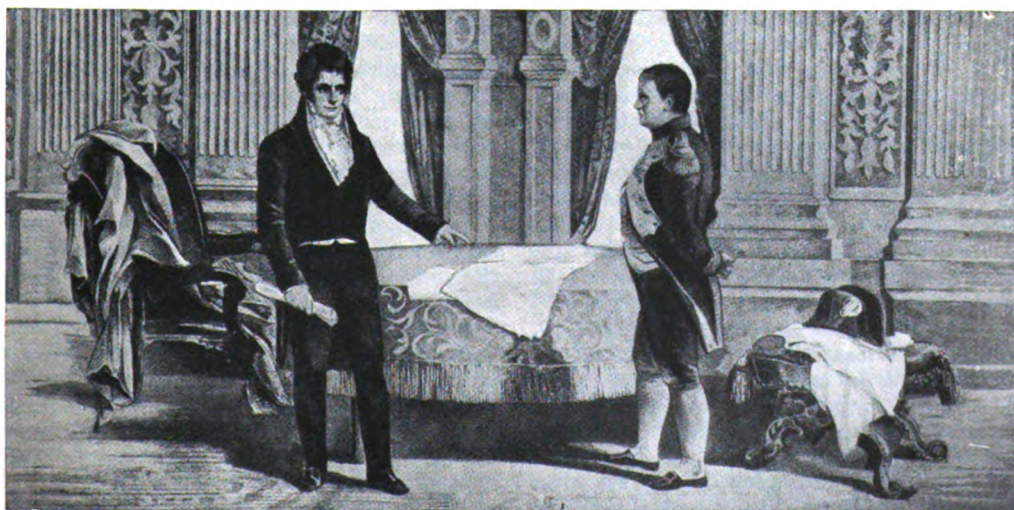
He invented the polariser which bears his name, improved the telescope in various ways—one being the simple yet effective scheme of thinly coating the object-glass with silver, to prevent damage to the eye when viewing the sun. He greatly increased the efficiency of electric lighting, and, eleven years before his death, which occurred in Paris on February 11, 1868, measured the actual velocity of light. There had previously been some brilliant guesses and some close calculations, but Foucault fixed it for all time at—to put it into English figures—about 185,000 miles per second. Our Royal Society rightly honoured Foucault with its Copley medal. The results of his work are reflected in many directions where the pure science of the savant has been turned to account in the everyday life of the man in the street.

ROBERT FULTON

The First Successful Steam Navigator

Robert Fulton was born in 1765 at Little Britain, Pennsylvania, a name now changed,

THE STEAMSHIP "CLERMONT," BUILT BY ROBERT FULTON IN 1807

in his honour, to Fulton township. His parents, who were poor Irish emigrants, were able to give him only a meagre education, yet, though put to work at an early age in the shop of a Philadelphia jeweller, he managed so well to teach himself that he was able to make a tolerable living as a painter of portraits and landscapes. He took an important step when, in 1787, he set out with Benjamin West to study art in Europe. He was destined soon to lay aside his brushes and canvas, and devote himself to engineering. Boulton and Watt were at the zenith of their fame as engine-builders; the Duke of Bridgewater, with the help of rare James Brindley, was building canals; and Fulton came to know them all, to study engine-building, and to help to cut canals for England. Crossing to Paris, he began his experiments with submarine vessels and torpedoes (see page 2760), and gave Napoleon the opportunity of possessing the first steam warship ever built. That was two years before the battle of Trafalgar, but the chance passed. Napoleon refused the steamship, just as, later in the century, Napoleon III. refused the armoured steam battleship which John Ericsson offered him.

During his early attempts Fulton's boat collapsed on the Seine, and his engine dropped into the depths. Luckily, he made the acquaintance of Chancellor Livingstone, at that time American diplomatic representative in Paris. Livingstone himself had original ideas as to steam navigation, and, prior to leaving home, had obtained from his Government an exclusive privilege for navigating the waters of New

ROBERT FULTON OFFERING HIS INVENTION TO NAPOLEON

York State. He encouraged Fulton to persevere, financed him, and obtained an extension of the privilege referred to. Fulton bought an engine from Boulton and Watt, and carried out successful experiments on the Seine.

Then he returned to England, and, going to Scotland for the trial of the "Charlotte Dundas," was present on her first trip, examined her mechanism, and was allowed to go without reserve over the plans of Henry Bell, who was in due time to fashion the famous "Comet." A second engine was ordered by Fulton from Boulton and Watt, but this one was sent across the Atlantic, where Fulton built the "Clermont," so-called after the residence of his friend and financier, Livingstone.

It is commonly assumed that Fulton was the first man to float a steamship on American waters. This is not the case. The insolent restrictions imposed by Great Britain on trade in the New World, restrictions only removed by the War of Independence, had kept the Americans in absolute ignorance of engine-building, and that during a time in which Watt had improved the engine from the simple pump of Newcomen into the rotative engine suitable for a variety of power purposes. With the removal of legislative limitations, the Americans began at once to scheme for the utilisation by steam-power of their own splendid inland waterways. Twenty years before Fulton got his vessel afloat in American waters a little canoe was propelled along the Delaware by steam-driven paddles. Its builder was John Fitch, of Connecticut. He later built a steamer with paddle-wheels in the stern, and in 1790 actually opened a steamship service between adjacent towns on the Delaware, failing apparently because his engines took up too much room to allow the craft to carry sufficient passengers or cargo to return a profit. He died heartbroken and in poverty nine years before Fulton began his more successful operations in the West.

Then a Colonel John Stevens, who was half a century before his time, launched, in 1804, a steamer propelled by submerged twin screws! His engine still exists, in working order, at the Institute of Technology bearing his name, at Hoboken, New Jersey. His idea was excellent, but he was ahead of the mechanical arts of his age; and when he next appeared it was with a paddle-steamer, only a few days in the wake of Fulton's. That of Stevens, denied access to the Hudson by Fulton's monopoly, was the first steam-driven craft to go to sea. She steamed from New York to Philadelphia, where she plied for many years. That was four years before Bell headed the little "Comet" out to sea. How, then, stands the case of Fulton?

He was the first to make the steamship a practical success in America. The lessons that he had learned of Symington and Bell were of eminent service to him; but, despite the advance of public opinion in America on the question of steam navigation, he was hampered, discouraged, and ridiculed from beginning to end of his building of the vessel. Unsympathetic critics spoke contemptuously of "Fulton's folly," declared that the ship could never be completed; that if it were it would not float, and that if it floated it would be of no use. Fulton went doggedly on, building a vessel round his Birmingham-made engine, but fashioning the paddle-wheels himself and coupling them to the engine with his own hands.

The "Clermont," on August 17, 1807, began her trial trip from New York to Clermont, proceeding next day to Albany. She returned to New York on the following day, completing a journey of 300 miles at an average speed of five miles an hour. It was a great day for steam navigation. Fulton's predecessors had never quite emerged from the experimental stage; and though a son of Colonel Stevens was out a few days later with a practical little steamship, Fulton was, after all, the real pioneer of true steam navigation.

A picture of the scene during part of the "Clermont's" voyage is worth recalling to-day when we are but newly recovering from the effects of the aeroplane's coming. The steamship is making her way in the dusk along a crowded waterway, and one who was on board describes the effect upon the crews of other vessels, "Notwithstanding the wind and tide were adverse to its approach, they saw with astonishment that it was rapidly coming towards them; and when it came so near that the noise of the machinery and paddles was heard, the crews, in some instances, shrunk beneath their decks from the terrific sight, or let their vessels run ashore; whilst others prostrated themselves and besought Providence to protect them from the approach of the horrible monster which was marching on the waves and lighting its path by the fires which it vomited." The success of his vessel gave Fulton and his partner, Livingstone, what should have been a monopoly

of the Hudson for twenty years; but they made very little out of their venture, and the concession was annulled in the law courts before it had run its course.

Fulton built other ships; one, the "Fulton," launched in the year of Waterloo, was the first steam warship. Others like it might have been Napoleon's at the time that he was scouring the seas for ships to carry over from Boulogne to England his "army of invasion." Several minor inventions stand to the credit of Fulton, who was a creative genius of high order, but it is with the steamship, the submarine, and the torpedo that his name will always be associated. A glance at our Parliamentary debates for 1802, when Earl Stanhope described to the House of Lords the warlike inventions of Fulton, "the terrible American," as he was popularly known, serves to recall an impression of the alarm which his name and fame inspired in our land. He died at New York on February 24, 1815.

MANUEL GARCIA

The Singer who Discovered the Vocal Cords

Manuel Garcia, inventor of the laryngoscope, was born in Madrid on March 17, 1805. He was the son of Manuel del Popolo Vicente Garcia, of Seville, famous in his day as singer, teacher of music, and composer of many successful operas. The Garcias were eminent singers for several generations, and have been characterised as "representative artists, whose power, genius, and originality have impressed a permanent trace on the methods of vocal execution and ornament." But Manuel Garcia was far more than a singer, and his work lives in the health of thousands who owe their life to his researches.

Garcia's early life was eventful. While his parents were on their travels he was left with his grandparents in Madrid, but in the year of Waterloo he followed them to Naples, where Murat had made the elder Garcia first tenor in the Royal Chapel choir. Manuel lived ninety-one years to recall the trial and execution of Murat, which he perfectly remembered. Proceeding with his parents to America, he had many adventures with them while his father was producing opera in New York and Mexico. On their return, bringing with them a fortune, they were held up by Mexican bandits, who robbed them of all except a packet of gold—a very small portion of the whole. Excited by his experiences of travel, Garcia resolved to be a sailor, but his mother's entreaties prevailed on him to join his father in Paris as vocalist and teacher of singing.

At the age of twenty-four he quitted the stage, and devoted himself to the teaching of singing and to the study of the human voice, and was appointed in 1830 a professor at the Conservatoire of Paris. Garcia was in his time the finest exponent of the antique florid style of singing, characteristic of Italian opera, and was regarded as the first teacher of the art; and after introducing to the stage many admirable singers he published volumes, which are still of interest, entitled "Memoir on the Human Voice," 1840; "Treatise on Singing," 1841, and others. The famous Malibran, one of the greatest operatic singers who ever lived, was a sister of Garcia; he had watched her development, under his father's tuition, from a child with a sweet, natural voice into a supreme songstress; and realised that there is almost no limit to the improvement in vocal production which a sound method of teaching may effect.

The permanent interest of Garcia's writings lies, however, in the fact that they record not only the experience of a great virtuoso and teacher, but also the reasoned conclusions of a physiologist. Garcia studied the throat and larynx more closely than surgeon had ever done, and as the result of his long-sustained endeavours gave to humanity the laryngoscope. It is an extraordinary invention, if only because of its extreme simplicity. The laryngoscope consists essentially of a tiny round mirror, attached by its rim to a long, thin handle, to which it is inclined at an obtuse angle. This laryngeal mirror is introduced by the surgeon, or, as in Garcia's practice, by the teacher of singing, into the back of the mouth-cavity of patient or pupil, over the throat. It serves the double purpose of reflecting light down on to the vocal cords and of reflecting their image to the eye of the observer. Light is supplied to the laryngeal mirror from a lamp, by means of a second larger, circular mirror or reflector, attached to the head of the observer, who looks through an aperture in the centre of this reflector. The whole instrument, practically as now used by the medical profession, was the invention of Garcia, who says:

"One day in the autumn of 1854 I was strolling in the Palais Royal when suddenly I saw the two mirrors of the laryngoscope in their respective positions as if actually before my eyes. I went straight to Charrière, the surgical-instrument maker, and, asking if he happened to possess a small mirror with a long handle, was supplied with a dentists' mirror. Returning

home, I placed against the uvula the little mirror (which I heated with warm water and carefully dried); then, flashing on its surface a ray of sunlight, I saw at once the glottis wide open before me, so fully exposed that I could see a portion of the trachea. From what I then witnessed it was easy to conclude that the theory attributing to the glottis alone the power of engendering sound was confirmed, from which it followed that the different positions taken by the larynx in front of the throat have no action whatever in the formation of sound."

Garcia had discovered an instrument which proved inestimably valuable in diagnosing many forms of disease; and five years later the Laryngological Society was established, with vastly beneficial results to humanity. Armed with the laryngoscope, the surgeon has created a new science—the science of curing diseases of the ear, throat, and nose. As the "Times" declared when the inventor died, "It is no figure of speech but a statement of demonstrable fact that millions of human beings have been benefited by Manuel Garcia's invention."

Garcia's career as a teacher of singing was one of unprecedented length. He founded famous schools in England, France, and Germany, and had many illustrious pupils, among whom the greatest was Jenny Lind. Fifteen years her senior, he survived his illustrious pupil nineteen years. His hundredth birthday was celebrated with many expressions of regard; on that day he paid a visit to King Edward, and was publicly banqueted. He had long made his home in England, and died in London on July 1, 1906, aged 101 years and four months.

RICHARD JORDAN GATLING

Inventor of Machines for Sowing Seeds and Slaying Armies

Richard Jordan Gatling was born in Hertford County, North Carolina, on September 12, 1818. Although famous chiefly as the inventor of the most terrible engine for the destruction of life known to his generation, he deserves a place in the roll of men honoured for their contributions to the machinery by which the employments of peace are furthered. His father was a prosperous slave-owning cotton-planter; and as Whitney's cotton-gin had made it necessary to employ negro labour for the cheap production of the vast quantities of raw cotton with which the contrivance could deal, so these two, ingenious father and talented son, devoted their energies to bettering the means of producing the cotton for the employment of their slaves. The great industry built up in the United States in agricultural implements may be dated from the invention by the Gatlings of their machine for sowing the seeds of cotton and thinning out the plants.

The younger Gatling proved one of those creative geniuses whom it was the good fortune of the United States to produce in abundance during the nineteenth century. Thus, convinced that the paddle-wheel was not the best means of propelling steamships, he invented a screw propeller. This, the first of his unaided designs, was brought to perfection during his twenty-first year, but proved a barren labour, for on seeking to patent it he found that he had been anticipated by John Ericsson. He then devoted himself to the production of a machine for sowing rice, which in time he adapted to the sowing of wheat in drills. Afterwards he produced a machine for breaking hemp, and a steam-plough, which proved too early for the farmer.

Establishing himself in St. Louis, he began the manufacture upon a large scale of his various machines, the use of which had a very considerable influence upon agricultural practice both in the United States and in Europe. While engaged in this work he found time to qualify as a doctor, but the outbreak of the Civil War directed his energies into a new channel. Gatling now essayed the task of improving the firearms in use, and, although he had never previously studied the question, he succeeded, in the course of little more than a year, in evolving the first of the famous Gatling guns. It was essentially a development of the revolver-pistol. The ten gun-barrels, grouped around and revolving about a common axis, with which they lay parallel, were revolved by a handle, and the speed at which the projectiles were discharged depended upon the rate at which the barrels were caused to revolve. For every revolution of the entire gun-barrel the whole ten tubes which it comprised were each fired once.

The weapon was an immense advance upon anything previously designed, but it came too late to be extensively employed in the Civil War. The curious point is that Gatling, who had been a slave-owner, sold his gun not to the army which was fighting for the right of free citizens to make slaves of their fellow-men, but to

the Federal Army. A dozen Gatling guns were used by General Butler, but it was not until the conclusion of the war, by which time Gatling had improved his weapon, that it was officially adopted by the Federal Army. The first Gatling fired 250 bullets per minute; later guns fired 1200 in the same time. Gatling continued to invent, and late in life produced a gun-metal of steel and aluminium. He died in New York on February 26, 1903.

SARAH ANN GLOVER

The School-Teacher who Opened the World of Music to Millions

Sarah Ann Glover, "inventor" of the Tonic Sol-Fa system of musical notation, was born at Norwich in 1785, and was a teacher there. She performed an astounding feat by placing a knowledge of music within the reach of the masses. The old staff notation, with its lines and spaces, is always regarded at first by the learner as a sort of specially cryptic shorthand; the doh, ray, me, fah of Miss Glover presents a familiar and intimate appearance, which is readily grasped. The actual invention is but a surprisingly short step from the solfeggio of Guido Aretinus, who lived in the eleventh century. Aretinus noted that in the melody of an ancient hymn the notes on which the successive phrases begun were identical in order with the six notes of the hexachord, and he adapted the syllables to which they were allied in a certain verse of the hymn, as names to represent the degrees of his new scale. He thus had ut, re, mi, fa, sol, la. Seven centuries later, the lower doh was substituted for "ut," while "si" was added as the note above the "la."

Miss Glover had thus a good and ancient foundation for her system, and she developed it with judgment and skill. Her important innovation was that the term "doh" was not applied any longer to a fixed note on the keyboard, but to the tonic or keynote of the piece, whatever that note might be. To make the system successful on a wider scale, however, greater energies than hers were needed. The man for the hour proved to be the Rev. John Curwen, a Nonconformist minister, born at Heckmondwike, Yorkshire, November 14, 1816. He at once realised the possibilities of the new notation, and gave up his life to spreading it abroad. Before his death, which occurred at Heaton Mersey, Lancashire, on May 6, 1880, Tonic Sol-Fa had spread into all lands as the easiest teaching system. Children readily learned it in the primary schools; they carried music into thousands of homes which had previously known no song. Choral societies and glee parties sprang up in all directions. Cantatas and oratorios, which had been mysteries irrevocably sealed from the masses, became easy of interpretation, not only in Great Britain, but in her Colonies; and even in savage and semi-savage lands natives learned to sing by the new method. The Tonic Sol-Fa student proceeds easily, when necessary, to the staff notation. Miss Glover, who lived to see her work famous, died at Malvern, on October 2, 1867. Curwen established her system, but he was always generous in insisting that Miss Glover was its originator.

ELISHA GRAY

One of the Two who Invented the Telephone

Elisha Gray, an inventor of the telephone, was born at Barnesville, Belmont County, Ohio, on August 2, 1835. Gray's career affords one of the most striking examples of the simultaneous yet independent origin of ideas. He invented an electric telephone, and went to the Patent Office at Washington to file his caveat. He found that he had been anticipated by a few hours. Alexander Graham Bell had that very morning entered particulars of his own electric telephone. The date, which marked one of the greatest advances in the science of human communication, was February 14, 1876. Neither man had tried to get ahead of the other; neither knew that he had a rival. To crown the coincidence, they entered their respective particulars not only on the same day but at the same office.

Looking back now upon the history of the telephone, upon all the steps taken by Reis and Wheatstone, and to the volume of prophecies outlining the coming of a telephone, it is surprising, especially in view of the success of the electric telegraph, that the world had so long to wait for the telephone. Conveyance of speech by an unelectrified wire was a method older than the general knowledge of electricity itself. Bell might have been earlier, for he had illimitable literary resources; Edison was unwontedly tardy. But Gray achieved wonders in so soon getting out his invention, for he was desperately poor, and had neither the over-mastering capacity and fecundity of ideas of Edison, nor the intellectual opportunities of Bell.

Gray's struggle was a hard one. Like many other commanding figures in the history of his times, he began life as an

artisan, working as a journeyman carpenter and mechanic, while at the same time reading hard at physical science. Like many a Scottish lad of recent times, he studied at college while earning his bread as a craftsman, and during this period worked ardently at the practical application of electricity to serious purposes. His first invention took the form of an electric switch and annunciator for telegraphic purposes, and his researches in this direction led him to the study of the conveyance of sound by electricity. He and others saw that there was but a little step to take from the old plain wire telephone to electrical transmission. Having invented an ingenious method by which sound could be reproduced at a distance by means of a current of varying intensity along a wire, Gray hastened at last to the Patent Office. The outcome must have been almost heartbreaking. He did not, however, surrender hope, and it was not until some years had passed that he was finally driven to realise that his patent was invalid.

HENRY GREATHEAD

Bitter as was his disappointment, Gray continued valiantly at work, and pursued lines in which he must have been dangerously near experiences of like kind with Edison. For, carrying on his experiments with telegraphy, he evolved systems of multiple telegraphy culminating in his being able to send eight messages simultaneously over the same wire. At the London General Post Office a system of this sort is in use, but it is not Gray's. They use there, also, the ingenious telautograph, which Gray invented, but that at the G.P.O. is not Gray's. His was the first ; that now in use is a much improved machine. Still, Gray's was a masterpiece of inventive genius. The sender of a telegram writes his message, and his handwriting is reproduced in facsimile at the addressee's end of the wire. The telautograph is positively uncanny to watch, as its spectral, spidery finger flashes backward and forward across the paper, writing the words inscribed by a hand miles away. Gray's invention was admirable, but if forced at any speed proved wanting, the receiving pen lagging behind the transmitting pencil. The invention has now been perfected by Mr. Foster Ritchie, and is no longer a show-piece at large post-offices but an indispensable adjunct to the daily work.

Gray's inventions, judging by his patents, which number upwards of sixty, must have been very numerous, and some of his labours may yet bear the fruit that he was denied. His system of electric bells for submarine signalling was brought back to mind a few months ago when the transmission of signals by means of this sort was declared emphatically successful. Although unable to claim public gratitude for his telephone, Gray was deservedly honoured by his generation, was granted the decoration of the Legion of Honour, and held a foremost place among the electricians of the day. He distinguished himself as a manufacturer of electrical appliances, and was not without material reward. But in America they speak of his career, overshadowed by his telephone misfortune, as tragic. He died at Newtonville, Massachusetts, on January 21, 1901.

HENRY GREATHEAD
The Inventor of Lifeboats

Henry Greathead, lifeboat inventor, was born at Richmond, Yorkshire, on January 27, 1757. After an apprenticeship to boat-building, Greathead spent some time afloat as a ship's carpenter, and learned from practical experience the bitter lessons of the sea. Returning to his home, he began business on his own account as a boat-builder. There was not a lifeboat in existence when Greathead put up his sign, nor would there have been one, in the North at all events, had not a great tragedy happened. This was in 1789. Now, as credit for the invention of the lifeboat is rightly accorded to Greathead, it is but just to note that he had already been anticipated.

In 1785 a coach-builder, Lionel Lukin, of Long Acre, London, a native of Dunmow, Essex, although he had but small acquaintance with the sea, was moved to pity for the sailor perishing in sight of the land to which he was returning; and this dweller amid the smoke and turmoil of London invented the first lifeboat, patented it in 1785, and succeeded by its use in rescuing several shipwrecked mariners. Lukin's lifeboat was ingeniously designed, and comprised a series of airtight chambers, to give buoyancy to the craft. Its fatal defect was its structural weakness, so that the sides would collapse upon slight impact. The germ of a fine idea was in the Lukin boat, but the invention was soon forgotten.

THE GREATHEAD LIFEBOAT AS DEPICTED IN AN OLD ENGRAVING

The call to Greathead came in 1789. In that year occurred a terrible wreck. The ship "Adventure," of Newcastle, grounded on the Herd Sands, at the mouth of the River Tyne, and was battered to fragments by the breakers. Thousands of people stood upon the shore and watched the crew go to their deaths. Not a man was saved; not an effort was made from the shore to rescue. No known boat could have lived in such a sea; to have launched one would have but added to the tragedy. The position of the Tyne was typical of the whole country. Shipwreck meant death.

The wreck of the "Adventure," so tragically conspicuous, roused England in 1789 to the question of new shore-boats, as in 1912 the wreck of the "Titanic" roused the world to the question of better and more boats for ships at sea. To the credit of the people of South Shields, they originated the voluntary lifeboat service which has since become national. They offered a handsome premium for a boat which could go to sea in a storm and rescue a crew from the horror of a situation such as the whole population of the town had just witnessed. There were many competitors for the prize. Among them was William Wouldhave, the beadle of the parish church of St. Hilda, South Shields. He, without Greathead's practical knowledge of boat-building, had sound ideas, and some of these were eventually embodied in Greathead's invention. But Greathead's plan was incontestably the best of all submitted.

The Greathead lifeboat was quite unlike Lukin's. For a first essay it was an admirable boat. It was 30 feet long, 10 feet wide, and 3 feet 4 inches in depth, lined inside and out with cork, to give buoyancy equalling Lukin's, but greater resistance, and was propelled by ten oars, five on either side. Although of very light draught, the boat carried twenty people. It performed

admirably in its trials, was bought by the Duke of Northumberland, and, in 1789, presented to the people of North Shields. The Greathead lifeboat embodied principles not previously associated with boat-building, but was, of course, far from perfect. It could not, for example, free itself from water, nor right itself if upset. Nevertheless, it was a remarkable example of an invention to order, and Greathead lifeboats saved hundreds of lives before their supersession by the more scientifically built craft of which they were to be the forerunners. Greathead was richly rewarded during his lifetime, and in 1890 a memorial was erected in his honour at South Shields. It is gratifying to find the name of William Wouldhave on this memorial. Greathead died in 1816.

SIR GOLDSWORTHY GURNEY

SIR GOLDSWORTHY GURNEY
The Father of Incandescent Lighting

Sir Goldsworthy Gurney was born at Treator, near Padstow, Cornwall, on February 14, 1793, and, like Sir Humphry Davy, was vowed to surgery. As a fact, he did qualify, and was established in practice at Wadebridge, and there was considerable discontent among his patients when he took a partner and turned over the practice to him, while he gave his undivided energies to theoretical and practical mechanics. James Brindley carried out his fine engineerings feats without any education worth mentioning, and Gurney helped in a dozen directions to revolutionise the application of science to the uses of daily life without scientific training, apart, of course, from that necessary for his equipment as a doctor.

It was his fortune to live in Cornwall when Trevethick and Murdock were terrifying the country-folk by their experiments with steam as a means of locomotion, and the craft of the engineer began to call from that fortunate hour. But before he could give rein to his natural bent he devoted himself with enthusiasm to the principles of abstract science, and, when perhaps not nearly as well qualified as the average polytechnic student of today, delivered a series of popular lectures in London on the elements of chemistry.

A glance at the life of Lord Kelvin in these pages will show how utterly deficient in knowledge of experimental science England was even twenty years later than the age in which Gurney began his work. The horizon has broadened so considerably since that Gurney, who was really a very important figure in the renaissance of scientific learning in this country, is practically numbered with the forgotten heroes. He was one of the lesser men of light and leading to whose lectures Faraday, as shown in his biographies, was indebted. Gurney was one of the minor prophets of science, one who, like the contemporaries by whom Dollond was inspired, saw visions and dreamed dreams, but could not reduce them to practice. For example, immediately he saw the magnetic needle influenced by the galvanic battery, he declared that the process would be made the means of intelligible communication, and in his lectures he clearly foreshadowed the birth of the electric telegraph.

His first serious contribution to practical science resulted from his researches into the conduct of certain refractory substances under the influence of high temperatures. With his own oxy-hydrogen blowpipe he showed that a cylinder of lime could be brought to a state of dazzling brilliancy. That illumination has become famous as the "Drummond light." As a fact, it was Gurney's, and the man whose name it bears was merely the first to use it. Drummond, who was the author of the memorable saying, "Property has its duties as well as its rights," applied the equitable principle to the Drummond light, for which he was thanked and praised; he at once declared that he could claim no credit for the invention, as it was entirely the work of Gurney. But the light is still

known by its first name, and Gurney's share in it was recognised only by his receipt of the gold medal of the Society of Arts for the creation of the blowpipe upon which it depends. Today the burglar goes a-burgling with the Gurney blowpipe, but the honest toil of the engineer, facilitated by this indispensable invention, may be counted as a set-off.

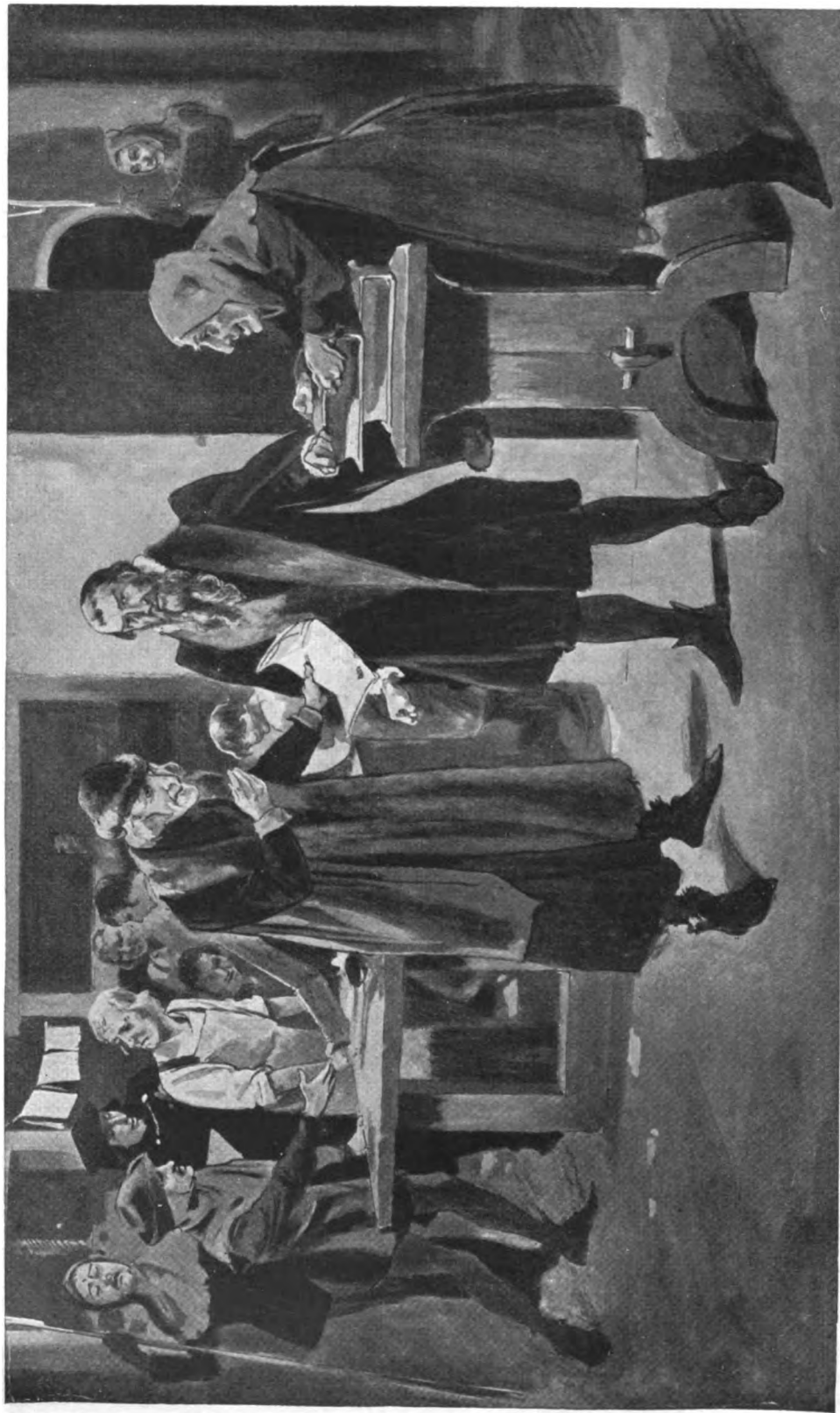
Gurney's interest in the question of illumination never waned, and, although as the father of incandescent lighting he was destined not to see his idea carried nearly to perfection, he had the gratification of lighting, as well as ventilating, the two Houses of Parliament. He devised an ingenious system of flash signals for lighthouses, which within the last year or so seems to have found favour afresh to the extent of a new development by the Admiralty. He next won gas from oils and fats, and if he had been living today he would doubtless have suggested the lighting of the islands of Oceania from their abundant coconuts, which in these days have become a staple oil-supply.

But Gurney's name, if it lives, as it deserves to live, will do so in connection with steam locomotion. It was his misfortune to be born half a century too soon. He was the first man to bring steam-coaches into public use. In 1827 he produced a steam-coach which carried twenty-one passengers. The steam was generated in a water-tube boiler fitted with steam drums or separators, for the purpose of supplying a sufficiency of dry steam for the cylinders. In this, or his second coach, was embodied his famous high-pressure steam-jet, which today we call the steam-blast. George Stephenson is credited with the invention of the steam-blast, but his was quite a different thing. Gurney's was applied to marine-engines, to furnaces—greatly stimulating industry—to the blowing out of congested sewers, and to the extinction of fires in collieries. In Gurney's hands the steam-jet was a contrivance of inexhaustible utility, as the hydraulic press was to Joseph Bramah. It helped to fan the blast of furnaces, but it also choked the fires which had raged for years in collieries.

One subterranean furnace that he attacked had been known for over thirty years as Clackmannan waste. Illicit distillers, carrying on their unlawful process in an old coal-shaft, had set alight the remains of an almost exhausted seam of coal, whence the fire, after putting the rogues to rout, spread far and near in the modern workings, until a seam of over thirty acres was involved. Thousands upon thousands of pounds were spent by the owner in the vain effort to check the fire. Then, after a generation, Gurney came to the rescue, built a steam-boiler over the raging furnace, and, with the infallible steam-blast, poured in under pressure such enormous volumes of choke-damp that the fire was at last extinguished, and the mine rendered workable once more.

The same type of steam-blast was embodied in the early steam-carriages of Gurney's make. He derived from its use an abundant supply of steam, but he did not trust his boiler over-much at first. For in a table which he issued, one of the items to be noted was a series of iron legs, or propellers which, "as the carriage ascends a hill, are set in motion and move like the hind legs of a horse, catching the ground and thus forcing the machine forward, increasing the rapidity of its motion and assisting the steam-power." As a fact, there was more in it than that. Gurney really believed that, at starting, the wheels would spin round and not bite; and the "propellers" were designed to give the coach a start as well as a lift uphill. But he had built better than he knew, and the iron legs did not appear after the first coach.

Before the "Rocket" was put on the rails, Gurney made a historic journey, from London to Bath and back, at fifteen miles an hour, over the public highway. It was the first triumph of steam upon the road, the first journey of note accomplished. He made many other trips, and aroused the hatred of the rustic groundlings, who shared the "no-machinery" mania. In the course of one journey the inventor was assailed when passing through Melksham, where there happened to be a fair. The carriage was held up by the pack, its occupants were stoned and beaten, and Gurney was carried to Bath unconscious. But he did not yield. The famous series of steam-coaches which Sir George Dance ran between Gloucester and Cheltenham were of Gurney's make. Four hundred journeys were accomplished by the service at a profit to the promoters. The iniquitous road-taxes of the period, referred to in other parts of this work, at last killed Gurney's coaches, as they killed others, and, after 1840, he devoted his attention to less disappointing concerns. His cheerful, fruitful, and valuable career closed at Reeds, near Bude, on February 28, 1875. He had been knighted in 1863.

THE LAST TRIBULATION OF GUTENBERG THE PRINTER, ON THE VERGE OF VICTORY

GUTENBERG, THE INVENTOR OF PRINTING BY METAL TYPES, BEING SOLD UP IN THE MOMENT OF SUCCESS BY THE MAN WHO FINANCED HIM

JOHN GUTENBERG

The Pioneer of Printing by Movable Type

John Gutenburg, commonly regarded as the inventor of printing by movable types, was born at Mainz at the close of the fifteenth century. Printing clearly records every story but its own. Gutenburg's life is enveloped in the mists of dubious tradition and demonstrable lies. One biographical expert overthrows another, as document after document upon which their predecessors have relied is proved to be a more or less clever forgery. Various cities have contended for the right to claim the cradle of printing; hence the cloud of false witnesses. It is difficult to sort out the few grains of wheat from the bushel of chaff in which they are concealed. As legend and forgery are more and more refined away, Gutenberg's hold upon his title is made by some to appear less and less secure; and the day will come when we shall be asked to believe that not Gutenberg, but another of the same name, was the inventor of printing. There exists a considerable literature on the subject which the ardent student must seek for himself. At the close of his uneasy reading he will be driven for his human facts back upon the old sources upon which, with all reserve, the present notice is based.

The art of printing from movable types had long been practised in China, but was unknown to Europe until the time of Gutenberg. Printing itself was well established, but that printing covered merely pictures carved upon wooden blocks, on which a line of explanatory matter would be cut at the bottom as part of the whole. Beyond that, the imagination of Europe had not reached, unless the much-disputed story as to Lourens Janszoon Coster be accepted. Coster is declared by his Dutch compatriots to have invented movable types, and, in 1445, to have printed a book with them. It is alleged, moreover, that one of his workmen stole some of the types and carried them from Haarlem to Gutenberg at Mainz. Like so many other of the perplexing legends, this story did not make its appearance until quite a century after the supposed event.

Gutenburg is supposed to have descended from a noble family, though one authority declares him to have been the illegitimate son of a monk. The father's name was certainly Geinsflesch, and the great printer is said to have taken his mother's name to carry on the style of a house of which she was the last member. But her name was Wyrich, and Gutenberg was her birthplace. Be that as it may, owing to political riots, Gutenberg, with his parents, or with his mother alone, had to flee his native city of Mainz when he was ten years of age. He grew up in Strasburg, and can be traced there in 1434, engaged as a mechanic. One of the familiar biographic items now assailed is the story of his discovering a new method of polishing stones and making improved mirrors, and of entering into partnership with the man who financed him. That he would need financing is certain. He always did. Whenever he appears with certainty, it is in connection with some loan, or lawsuit arising out of one, loans for himself or in respect of which he is the surety.

A certain Peter Schoeffer, a skilled worker in metal, was associated with him in his first attempts at type-founding, but John Fust was his partner. It is thought that Schoeffer may have originated the scheme for the types, for the plan was entirely novel. There had been some attempt at cutting types of wood, but the disadvantages of this are obvious. Printing did not reach its cradle until the first mould was formed into which molten lead could enter, and emerge in the shape of a letter, usable again and again as a type. The partnership with Fust, who found the money and shared the risk, but not, apparently, the labour, is fixed at 1450, and the famous Latin Bible was printed and published in 1456. Fust and Gutenberg quarrelled and went to law, with the result that the first-named gained the verdict and the press, and used it, with the help of Schoeffer, till the sack of Mainz, in 1462. Not until 1463 did Gutenberg get another press established, when he was assisted to that end by Dr. Konrad Humery. Gutenberg, however, died a poor man, five years later, in February, 1468.

They did not think of putting printers' names to the first books that were issued from the press, so there is not a book or part of a book in existence today bearing the name of Gutenberg. No one knew how famous he was to become, so no man sought immortality by painting his portrait. His supposed likenesses on medals with which we are familiar were all issued long after his death, and are purely imaginary portraits for which any man with normal features might have sat. But without imprint to book, or authentic portrait, Gutenberg stands to us, in spite of the claims of rivals, and in spite of the most searching analysis of the critics, as one of the towering benefactors of humanity. We might have had the printing-press without him; it must

JOHN GUTENBERG
From the statue by Thorwaldsen

inevitably have come sooner or later. But the evidence extant suggests that we should not have had it for long after but for him. He was the animating genius of the scheme. Schoeffer was not the only man skilled in metal work; there were, and had been, hundreds greater than he, but there had not been, nor did there then exist, any but Gutenberg capable of utilising the skill of the workman to this mighty end.

The knowledge of printing spread like lightning from Gutenberg's little press over Germany and Italy, and thence across other enlightened lands of Europe. Englishmen were too busy cutting each other's throats in the Wars of the Roses immediately to concern themselves with the new knowledge; and it was twenty-two years after the appearance of the Latin Bible before the art was adopted here. The hour brought Caxton, who was the first man to give us a book printed in England. Fifty years before, English had not begun to be taught in the land. French and Latin were the polite tongues of Merrie England. But Caxton and his followers gave form and fixity to the common language, and English printing was holding its centenary when Shakespeare was keeping his thirteenth birthday.

When we realise that had Shakespeare lived before Gutenberg all his works might have perished with him, we must agree with Lamartine that Gutenberg did indeed give the world a soul. Victor Hugo has traced with a sure hand the progress of the world from the invention of Gutenberg's art. "One sower heralds the other. Gutenberg in the fifteenth century emerges from the awful obscurity, bringing out of the darkness that ransomed captive the human mind. Gutenberg is for ever the auxiliary of life; he is the permanent fellow-workman in the great work of civilisation. Nothing is done without him. He has marked the transition from the man-slave to the freeman. Try and deprive civilisation of him, you become Egypt. The decrease of the liberty of the Press is enough to diminish the stature of a people. . . . A Gutenberg, discovering the method for the sowing of civilisation and the means for the ubiquity of thought, will be followed by a Christopher Columbus discovering a new field. A Christopher Columbus discovering a world will be followed by a Luther discovering a liberty. After Luther, innovator in the dogma, will come Shakespeare, innovator in art. One genius completes the other."

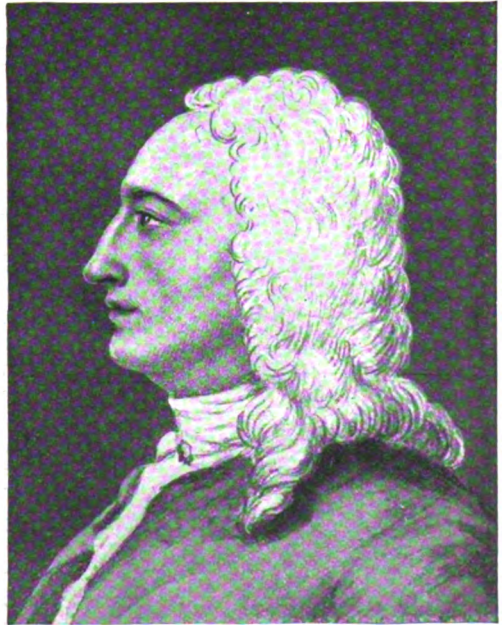
JOHN HADLEY

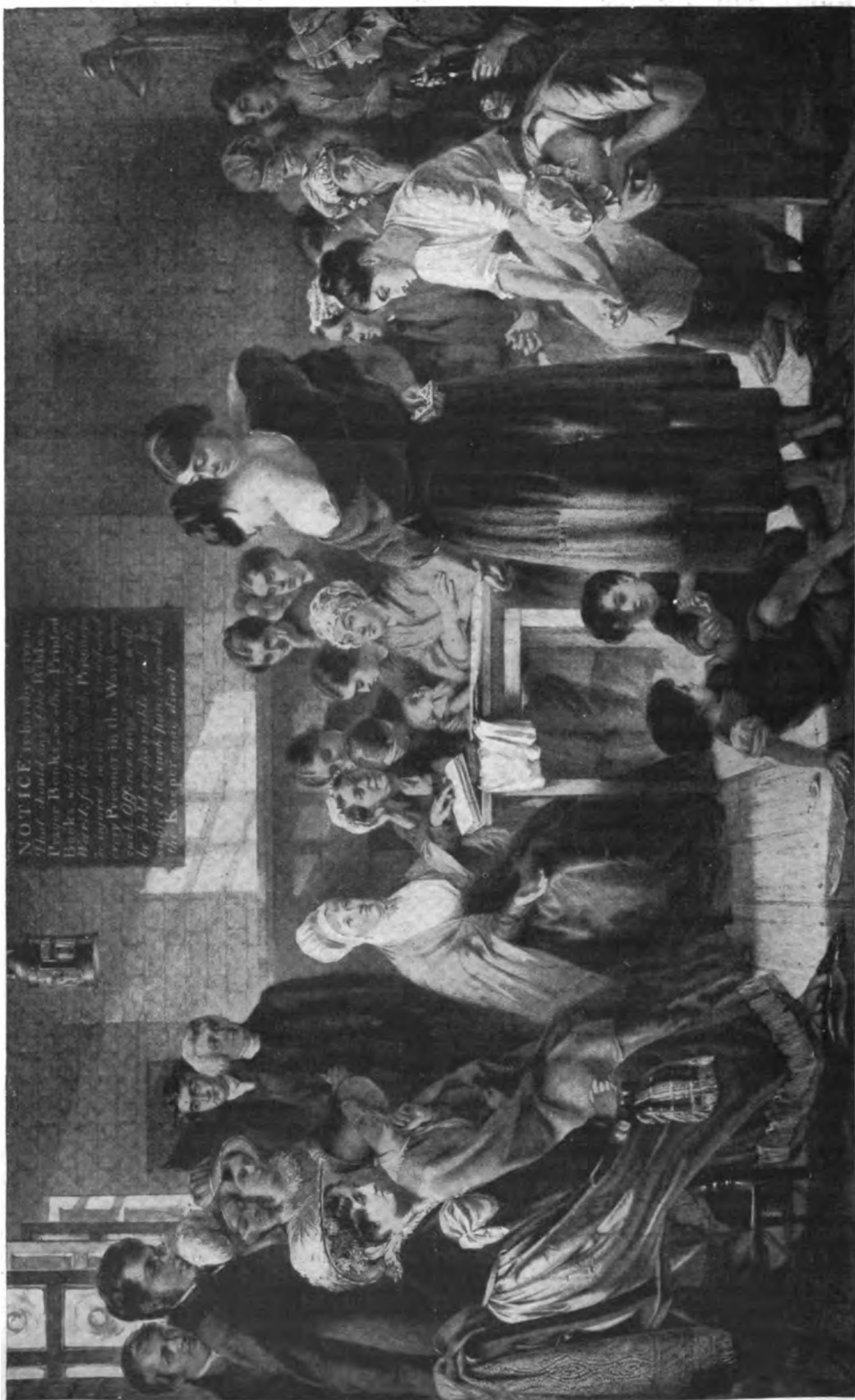
A Provider of Knowledge for Navigation

John Hadley was born in London on April 16, 1682, the son of a man of means. He early distinguished himself as a mathematician, and at five-and-thirty was elected a Fellow of the Royal Society. His claim to fame rests upon his perfection of the reflecting telescope and of the reflecting quadrant, still called by his name. Little more than a century earlier Galileo had tried in vain to induce his protagonists to look heavenward through the telescope of his fashioning. The phenomena he described could not exist, they said, because they differed from the teachings of Aristotle. When driven at last to admit the accuracy of his views, they calmly turned round and asserted that it must have been from some passage in Aristotle that Galileo had borrowed his idea! Hadley lived in a more propitious age, an age in which telescopes and their revelations were no longer "meete only for princes," as old Recorde, in his "Pathway to Knowledge," dedicated to Edward VI. of England, had declared. The prince for whom alone such knowledge was intended had at the time attained the ripe age of fourteen! Seeing how long mankind had to wait for the telescope, and that both Newton and Gregory left it very imperfect, while Newton actually barred the way to the refracting telescope, it is interesting to remember what they thought about telescopes in the day of Recorde.

He is discussing the report, even then surviving, as to Roger Bacon having possessed a telescope. "Great talke," he writes, in 1551, in the work cited, "there is of a glass that he made in Oxforde, in which men might see thinges that weare doen in other places, and that was judged to be doen by evill spirites. But I knowe the reason to bee goode and naturall, and to be wroughte by geometerie (sith perspective is a parte of it), and to stand as well with reason, as to see your face in a common glasse. But this conclusion, and other divers of like sort, are more meete for princes, for sundry causes, than for other men, and ought not to be taughte commonly." Hadley did not consult the will of princes, but worked quietly at his telescope until in January, 1721, he was able to produce to the Royal Society the first reflecting telescope really worthy the name. The Hadley telescope was an immense advance upon anything of the kind ever previously seen, and led to a great acceleration of work by astronomers. Encouraged by his initial triumph, Hadley produced a still better instrument.

In these days of huge reflecting telescopes created by the commendable pride of American millionaires, the Hadley telescope with its six-inch reflector and five feet of focal length must seem a trivial glass, but, in comparison with those it followed, it was as the locomotive "Rocket" compared with the old horsed trams in which coal was hauled with difficulty and pain.

Hadley's next invention was the reflecting quadrant. This, in its way and day, was as important to navigation as Kelvin's improved compass. There can be no doubt that Newton communicated the idea to Halley, and the latter claimed priority for Newton, but Hadley's invention was absolutely independent. The idea was in more than one mind. It was in Newton's, in Halley's, and in that of an ingenious Philadelphian named Godfrey. The latter, as well as Halley, contested Hadley's claim to priority of invention. The Royal Society, in considering the claims, decided that with regard to Newton, as the actual inventor or designer, there was not even probable evidence. Both Hadley's and Godfrey's inventions were original, they held, but Hadley's second form of quadrant was not only far superior to his first form, but to the final form of Godfrey's. It has developed into the sextant now in general use. Hadley died on February 14, 1774.

JOHN HADLEY

ELIZABETH FRY GATHERING HER EXPERIENCE AMID THE HORRORS OF PRISON LIFE

A VISIT OF ELIZABETH FRY AND HER FRIENDS TO NEWGATE PRISON IN 1816, PAINTED BY J. BARRETT

CONTINUED FROM 4579 CONTINUED ON 4805

PIONEERS

ELIZABETH FRY

The Sweetener of Prison Life

ELIZABETH FRY was born at Earlham, Norfolk, on May 21, 1780, the third daughter of John Gurney, a wealthy Quaker banker of Norwich. She early interested herself in the condition of the poor in Norwich, and her experience of the lot of the unfortunate people incarcerated in the gaol there led to her concerning herself—after her marriage to Joseph Fry, a London merchant—in the still more unhappy condition of the prisoners in Newgate.

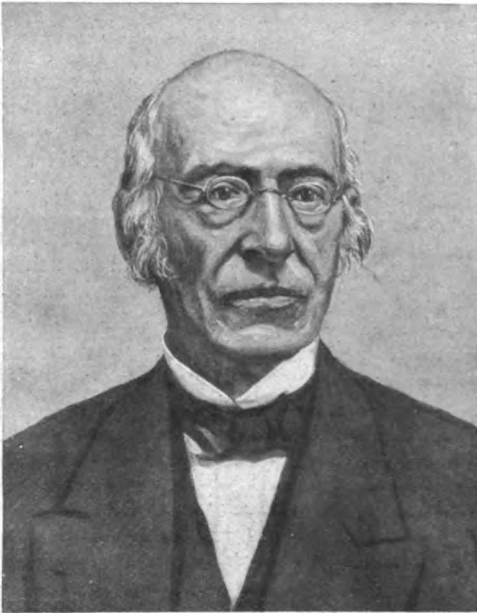
England had not yet emerged from barbarism. Capital punishment was still inflicted for petty larceny, and other offences as trifling. Samuel Rogers records that he saw "a whole cartful of young girls, in dresses of various colours, on their way to be executed at Tyburn." They had all been condemned on one indictment, he says, for having been concerned in—"that is, perhaps, for having been spectators of, the burning of some houses during Lord George Gordon's riots." Greville saw many boys sentenced to death, "to their own excessive amazement," on a similar count. "Never," said Greville, with great naïveté—"never did I see boys cry so." Capital punishment and transportation for men, women, and children alike were the stock regenerative agencies of the period.

The victims were herded together in prison like cattle in pens, without discrimination as to age, guilt, or innocence, the hardened sinner with the guileless child, the convicted felon with those not yet tried. Mrs. Fry found nearly three hundred women with their children penned up in two wards and two cells, without nightclothes or bedclothes, sleeping on the bare floor, cooking, washing, and sleeping in the same apartment. She pictured the scene to a Parliamentary Committee of the House of Commons. "The begging, swearing, gaming, fighting, singing, dancing, dressing up in men's clothes, were too bad to be described, so that we did not think it suitable to admit young persons with us." Single-handed she set herself to reform the whole system.

Beginning by clothing the destitute and relieving their pressing necessities, she taught and educated them, formed an association for their benefit, secured the separation of sexes, established a school and manufactory for them, provided for the comfort of those transported, and arranged for their reception and kindly treatment in their distant home. The prisoners submitted to her charm, sympathy, and goodness as if spell-bound. Morality, cleanliness, industry, and reformation were achieved by the work of this one woman. She extended her operations beyond the prison walls; she anticipated the Prisoners' Aid Society; she was half a century ahead of the Salvation Army in providing food, raiment, and shelter for the destitute; and she was equally as far before the Charity Organisation Society in exposing mendacity and fraud. She carried her campaign into the gaols of the large provincial cities, and then attacked the Continental system.

She made tours in Europe, inspected all the chief prisons, drew up and presented reports and suggestions to the various Governments and heads of States, and lived to see her suggestions adopted. Foreign rulers treated her as a friend and welcome adviser; men famous in science and politics and statecraft were proud to share her friendship. Yet while she was cleansing the prisons and indirectly helping to sweep away many barbarities of the criminal law of the land, she had a large family of her own upon which to lavish

her unflagging sympathy and affection. The bankruptcy of her husband brought her to sudden poverty, but, though her purse was exhausted, she continued her ministrations to the end. As minister and nurse and instructress her influence remained unabated.

Sydney Smith has left us a memorable picture of her and her work. "There is a spectacle which this town now exhibits that I will call the most solemn, the most Christian, the most affecting which any human being ever witnessed. To see that holy woman in the midst of the wretched prisoners, to see them all calling earnestly upon God, soothed by her voice, animated by her look, clinging to the hem of her garment, and worshipping her as the only being who has ever loved them, or taught them, or noticed them, or spoken to them of God! This is the sight which breaks down the pageant of life." Elsewhere he says that the beautiful spectacle he witnessed in the prison cell with the felons' saviour made him weep like a child.

WILLIAM LLOYD GARRISON

Before she died, Mrs. Fry had the satisfaction of knowing that practically all the reforms she had suggested had been, or were being, carried out at home and abroad. The real poverty of the last seventeen years of her life made no change in her programme of work, except that she could no longer help materially as had been her wont. Elizabeth Fry was an even greater prison reformer than John Howard. That the efforts of two such unwearying friends of the unfortunate should be required over a period of seventy years is evidence of the magnitude of the evils they fought. She died at Ramsgate on October 12, 1845.

WILLIAM LLOYD GARRISON

The Printer who Made the Land of Freedom Free

William Lloyd Garrison was born at Newburyport, Massachusetts, on December 10, 1805. His father, a drunkard, deserted his wife and family when the child was three years old, and was never traced. Garrison's mother, to support her children, became a nurse. William, after unhappy experiences of shoemaking and carpentering, was apprenticed to the printer of the "Newburyport Herald," and, after a short spell as a compositor, began to write for the "Herald" and other journals. When only nineteen he was appointed editor of the local paper, but at twenty-one took over, as editor and publisher, another journal, which he called the "Newburyport Free Press." Among the first contributions received was one from a woman who denounced the guilt of American slavery. That was the first occasion on which the subject had had consideration from Garrison, and within a few weeks he was writing, "There is one theme that should be dwelt upon until our whole country is free from the curse—it is Slavery." The seed was germinating.

It was at this time, too, that he received the rough little manuscript of some verses entitled "The Exile's Departure." The verses were signed merely "W." but Garrison was able to trace the writer through the postboy, and, riding over to East Haverhill to thank his shy contributor, and ask for more, he found an awkward, nervous, uneducated youth of nineteen, hoeing turnips in a corner of his father's little field. The poet was John Greenleaf Whittier, and Garrison was his first editor, as he was his first friend and adviser. The two remained friends for life. It was Garrison who pleaded with the Whittiers to educate their uncultured genius of a son, only to be answered, "Poetry won't buy him bread." At Garrison's suggestion, the poet redoubled his efforts at bootmaking to earn fees for the college course that he needed, and it may be admitted, therefore, that Garrison gave Whittier to literature.

Garrison's minor newspaper ventures may be passed over until we find him writing for and assisting to edit, in Baltimore, a paper

which ardently advocated the immediate abolition of slavery. His opinions on the subject had not altered from the first hour in which he read an obscure writer's forgotten poem, and his life was concentrated to the work. It was a perilous path that he had chosen, for to denounce slavery in a slave-owning State was a heinous offence in the eyes of the proprietors of the negroes. The enemy soon found a way past his defence, and succeeded in getting him charged with libel and imprisoned until friends paid his penalty.

Following a series of lectures on the subject, he established his famous "Liberator," and in spite of threats of violence and assassination, in spite of attempts by the Georgia Legislature at suppression, and in spite of mob violence from which he narrowly escaped with his life, he valiantly kept his paper going, telling and retelling the story of the equal birth and rights of all men of whatsoever colour they may be.

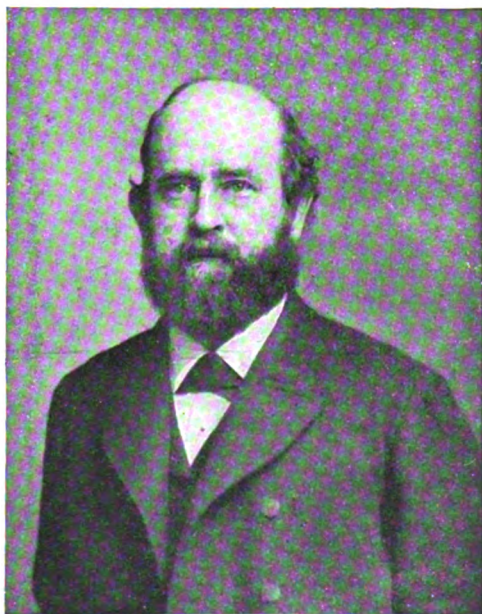
Garrison visited England, where he was warmly welcomed by Wilberforce and his associates, and established the American Anti-Slavery Society. During many years he was in constant danger from slave-owners and their friends, but he was absolutely fearless. At a great Fourth of July demonstration, with many angry and turbulent slave-owners present, he read the Declaration of Independence, and contrasted it with the principles of the infamous Fugitive Slave Law. Then he burned both, following this by similarly treating a copy of the Constitution of the United States. "And let all the people say Amen!" he cried. There was a roar of "Amens," but mingled with them were the cries of those who would gladly have taken his life.

His writings and speeches had a profound effect upon the public opinion of the United States, but the sacrifice to which he pointed was too heavy for many quite well-meaning people willingly to contemplate. "Mr. Garrison, you are too excited—you are on fire!" said one of these. "I have need to be on fire, for I have icebergs round me to melt!" was the retort. The Civil War was the last thing he desired or expected; he hoped to the last that moral suasion and the appeal of humanity would prevail. But then, as now, cotton was king in the Southern States, and that king's disciples would not let their victims go until driven, at the cannon's mouth, to the renunciation.

Garrison lived to see peace re-established and his labours crowned with triumph. His admirers recognised the value of his labours by a public subscription representing £6000. But his richest reward was the knowledge that, thanks in an enormous degree to his own efforts, there remained not a single bondman in the American Republic, which became at last, in fact as in name, free. Garrison died in New York on May 24, 1879.

HENRY GEORGE

The Proposer of the Single-Tax System

Henry George, the American social economist, was born at Philadelphia on September 2, 1839, and at an early age started his education by a roving experience of life. He went to sea as a lad, and presently found himself on the West

HENRY GEORGE

Photograph by Elliott & Fry

Coast of America, where he settled in California, and took to printing as a trade. Gradually he worked his way from the compositor's case to the editorial chair, thought out his economic philosophy by the way, and condensed it into a single book. When this book, for which he is known throughout the world, was published he was in his fortieth year. It was wholly a product of the West, and was issued in California, in 1879, before it was offered to the Eastern States or to Europe. The title, "Progress and Poverty," outlines the aim of the book in which the life of this vigorous thinker is crystallised.

When "Progress and Poverty" appeared in New York, in 1880, and in Europe the next year, it took the world by storm. Literally everybody who made pretensions to a knowledge of political and economic principles read it. During the next seven or eight years Henry George was often in this country forwarding his propaganda, which had a deep effect, and by undercurrents is largely influencing thought to-day. During the 'nineties he spent his time chiefly in New York, where he attempted, through administrative action, to gain a foothold for his social theories. Twice he stood as a candidate for the mayoralty of New York, where he had started a newspaper of his own; and it was during the second of these contests that, on October 29, 1897, he died suddenly of heart failure.

HUGO GROTIUS

He had written several other books, developing various phases of his economic theory, but none of them attained the popularity or, indeed, possessed the spontaneous force of the work which has made "betterment" and "the taxation of land values" an active policy accepted even in some Conservative circles.

George's attention had been arrested by the strange fact that with the increase of general wealth goes, under modern conditions, an increase of poverty below a certain line. He contended that, in the cities, there is more and worse poverty in proportion to the advance of invention and production; and he asked why this is. His answer was that the rise in the value of land caused by men aggregating together lays a tax upon industry, and that, through enhanced values, rent absorbs an unfair share of the profits of human enterprise. Rent, labour, interest, each takes its toll. His remedy was to tax out rent, and leave the division of profits between labour and capital. He contended that as the enhanced value of land is caused by the aggregation of population in limited areas, that value should be used to defray the cost of the public wants of the people who have called it into existence. Indeed, he would have all public expenses met out of one tax, and that a tax on land. This, he argued, would stimulate industry by freeing it from hampering charges, and would equally distribute the burden of taxation.

The idea was widely entertained at first that Henry George's proposals were a form of Socialism, but as he developed his theories it became clear that they amounted rather to a new method of taxation. He believed in free competition when the ground had been cleared from what he regarded as unjust private appropriations. "Progress and Poverty" will remain a book that must be read by all who study social economics. It cut right across many accepted economic theories, and claimed attention not less by its lucidity of style and aptness of illustration than by its originality of thought and earnestness of purpose. The thoughts of Henry George, in fact, have been creeping into legislation and administration in a realised form almost ever since they were given to the world.

HUGO GROTIUS

Who Applied Reason to Foreign Affairs

Hugo Grotius, or Huig van Groot, to give him his Dutch name, was born at Delft on April 10, 1583. As the man who laid the foundations of International Law he has had a great and beneficent influence on the world, which will be recognised more and more as the history of a true civilisation comes to be written.

Men of distinction often seem to group themselves in boyhood into two opposite categories—those who were accounted dull and those who were unmistakable prodigies. Grotius was one of the prodigies. He went to the University of Leyden at the age of eleven, and entered public life at the age of fifteen, when he accompanied the embassage

of Olden Barneveldt to the Court of Henry IV. of France. On his return to Holland he set up as a lawyer at the age of sixteen, and when he was twenty-four was provincial fiscal-general.

Grotius was not only one of the finest scholars of his time, but one of the most attractive men, as is proved by his continuous success. As a lad he had been a great favourite at the French Court. His own countrymen accepted him readily at his true worth. The only prejudice that could bar the way of such a man was the religion of those contentious times, and religion came near to being his undoing. Holland was divided in Protestant theology between Arminianism and Calvinism. As might be expected, Grotius was on the more liberal-minded side, as also was his friend Barneveldt. But the patriotic services of Barneveldt, and the genius of Grotius, availed nothing against the bitter narrowness of the Calvinistic experts in theology. The two friends were seized by their Christian opponents, and Barneveldt was put to death, while Grotius was imprisoned for life in the castle of Lovenstein.

In prison Grotius was allowed to continue his studies, and their remarkable range and amount opened a way for his escape. Heavy boxes of books were taken in and out of the castle for his use, and finally he was packed by his devoted wife into a return box, and so escaped to France. There the French King, Louis XIII., gave him a temporary pension. Later he was invited to Sweden, and became the Swedish Ambassador to France—a post which he held for eleven years. Returning from Sweden to his native country in 1645, he died (August 29) at Rastock. He had long been, in a quiet way, a great international figure.

In 1625 Grotius published his " De Jure Belli et Pacis," a book he had been writing for many years, and it has since been taken as the foundation of International Law in war and peace. Before his day there was complete confusion as regards war-making, and conscience had no legal ground on which to rest its claims when wars broke out without any show of reason, and were conducted without any semblance of humanity. Since the publication of this great work—which was welcomed generally by the European Powers—a great body of International Law has been amassed, and increasingly the belligerents are made amenable to the public opinion of the world at large, which in times of peace they have accepted in the form of international agreements as to what are legitimate causes of war, and how hostilities should be conducted. When the world is sickened of brutal, useless, senseless wars, and attains to the reasoning state of rational manhood, it will look back and see that the seeds of its newly gained common sense were sown by the Dutch jurist, Grotius.

Apart from his work for posterity as a jurist, Grotius distinguished himself in his own age. An acceptable ambassador, a graceful poet, a profound scholar, one of the best of the Renaissance Latin stylists, a liberal-minded theologian in times of fanatical controversy, he shines forth from his troublous generation a man worthy in every way of the distinctive place he holds in the vanguard of modern civilisation.

JOHANN HERBART

JOHANN FRIEDRICH HERBART
Who Brought Psychology into Education

Johann Friedrich Herbart, who in his day was regarded only as the philosophic professor who succeeded Kant, and now is accepted as the father of psychology as applied to education, was born at Oldenburg, May 4, 1776. He was educated under Fichte, at that amazingly prolific educational centre, Jena. Later, after a period as private tutor, Herbart became Professor of Philosophy at Göttingen (1805), Königsberg (1809), and again at Göttingen (1833),

where he died, August 14, 1844. It was at Königsberg that he succeeded Kant, and there he established his practising school, and conducted his experiments.

Herbart's reputation in the most modern world of education, among those who talk the curious language of psychology, is great. It is also quite recent. When the Rev. R. H. Quick wrote the first really "live" English book on education—"Educational Reformers," a book worth a barrow-load of dry treatises—he only mentioned Herbart in a footnote. No book on education is now complete without a chapter, if not a whole section, on this student of the psychology of the child-mind.

Herbart took up educational work, and especially educational theory, at the point where Pestalozzi left off. Pestalozzi relied on the training of the senses through observation, but he did not show how the mind gathers up and uses its stores gleaned by observation. But Herbart, in the queer language of the schools for training teachers in simplicity, "showed how the product of sense-perception could be converted into ideas, through the apperceptive process, and how knowledge in turn could thus be made to bear a moral character through the processes of instruction." Herbart made the moral presentation of the universe the chief aim of education, whereas Pestalozzi had largely been satisfied with studies from the physical world. It was Herbart who put education on a scientific basis, whereas, before him, Rousseau's educational schemes had been more or less flimsy fancies, and Pestalozzi had used rule-of-thumb methods.

Professor Paul Monroe, of Columbia University, summarising Herbart's position, says he regarded the soul as a unity, not endowed with intuitive or inborn faculties, but a blank at birth, possessing, however, the power of entering into relation with its environment through the nervous system. Through this sense-perception the whole mental life is developed. Contact with Nature and contact with society are the two main sources of the "presentations" which come to the child. The chief characteristic of the mind is its power of assimilation, and this assimilative function Herbart terms "apperception." He regards education, which determines largely what presentations the mind receives, and also the manner in which they are combined into higher mental processes, as the chief force in shaping the mind and character. Assimilation, or apperception, is thus the pivot-point of his psychological system. Assimilated ideas lead to action, action determines character, the *will* grows by this process, and the outcome of education becomes essentially ethical. Herbart's first work was entitled "The Æsthetic Presentation of the Universe the Chief Aim of Education." The shaping of the will and determination of conduct is the aim of educative instruction, which follows upon the presentation of the outside worlds of Nature and society to the mind. It is the business of the instructor to engage a many-sided interest. This he can do by a choice of the right materials for making "presentations" to the mind, and by arranging them harmoniously with the psychological development of the child. To this end Herbart prepared, and his followers have extended, a scheme of studies, in careful co-ordination.

Herbart himself maintained that the Homeric poems furnish the best material for the education of boys. His theories can be found in his two mature books, the "Science of Education" and "Outlines of Educational Doctrine." He has been supported by an active, not to say aggressive, band of followers, constantly growing in number as education becomes more highly developed on its academic side.

Unquestionably, Herbart's influence on education has been extremely valuable in concentrating attention on the mind of the child—the instrument through which alone the educator can work—but there is some danger that acquaintance with the profuse terminology of scientific education may mislead inexperienced teachers into fancying too soon that they have mastered what can only be really understood when it is put carefully into practice.

SIR ISAAC HOLDEN

An Improver of Wool-Combing Machinery

In the story of the improvement of the machinery that enables the people of the temperate zone to clothe themselves with woollen goods, three Bradford names stand out conspicuously—the names of Lister, Donisthorpe, and Holden. The last of these has claims to notice apart from the West Riding trade; he was one of two simultaneous inventors of the lucifer match.

Isaac Holden was born at Hurlet, in Renfrewshire, on May 7, 1807, of Cumberland parentage, his father having moved to Scotland after farming and lead-mining in the English Lake country. The family was poor, and when he was ten years old Isaac was a "drawing-boy" for two Scottish hand-weavers. Then he was put

to learn the shawl business at Paisley. But his health gave way, and so he studied to become a teacher. His first engagement, as a teacher of mathematics, took him to Leeds. Later he passed to a grammar school in the neighbourhood of Huddersfield, and finally spent eighteen months in a school at Reading. Here it was that he invented the lucifer match as an aid to economy in the time he devoted to study.

He now had thoughts of joining the ministry, but his health again broke down, and he returned to Scotland. As an easier form of work, he accepted the position of bookkeeper in the firm of Townsend Brothers, at Cullingworth, near Bingley, and thus came into contact with the industrial processes which he was eventually to improve so greatly.

Watching the work of the mills from an outside standpoint, Holden saw clearly some of the needs for improvement, and determined to become an inventor. In 1846 his work had grown to be so valuable that he was able to join with Lister, who had bought up Heilmann's chief Alsatian patent, and the two started business abroad as well as in Yorkshire. Holden now thought of the "square motion" machine, and Lister took out the patent in conjunction with him. The details of the succession of patents that were registered as improvements by the three men mentioned, separately, in various combinations with each other, and which cost Holden alone £50,000 in experiments, are too technical for enumeration here, but they carried the earlier processes in the manufacture of woollen goods to the perfection which gave Bradford the command of the trade of the world.

Holden was made a baronet in 1893. He represented various Yorkshire divisions in Parliament between 1865 and 1895. His death occurred at Oakworth, near Keighley, August 13, 1897. His great wealth was generously expended during his lifetime on public objects.

GEORGE JACOB HOLYOAKE

An Inspirer of the Co-Operative Movement

George Jacob Holyoake, a prolific writer on the co-operative movement, and founder of an ethical system which he named "Secularism," was born in Birmingham on April 13, 1817. Secularism is described as "a system which bases duty on considerations purely human, relies on material means of improvement, and justifies its beliefs to the conscience irrespective of atheism, theism, or revelation."

In his "Bygones Worth Remembering," written at the age of eighty-eight, Holyoake traces, with underlying pathos not untouched with humour, the causes which led him to break away from the Calvinistic teachings of his boyhood. He came under the influence of Robert Owen, the well-known social reformer, and discovered that morals are affected by environment and heredity. Gradually rejecting the whole body of current theology, it was rapidly brought home to him that the law held no parley with heterodoxy. When lecturing at Cheltenham, in 1841, on "Home Colonies," an irrelevant question from an unfriendly listener drew a spontaneous reply that exposed Holyoake to the charge of blasphemy. He made a spirited defence, but his speech was unavailing, and he was sentenced to six months' imprisonment.

In January, 1846, he established the "Reasoner," which he edited in his own name. Holyoake was a prolific writer on co-operation, and his first article in his paper had reference to that question. His "History of Co-Operation in England" and the "History of the Rochdale Pioneers" are now regarded as classical works on the subject. The latter book has been translated into several European languages. Holyoake defines co-operation as "the equitable division of profits with worker, capitalist, and consumer concerned in the undertaking." He points out the fallacy of considering co-operation as a means of abolishing competition, and quotes Owen's view that it is the "corrector of the excesses of competition in social life."

In his "History of the Leeds Industrial Co-Operation Society," Holyoake deals with the economic advantages to consumers which arise out of adopting what is known as the Rochdale system. Members buy at market price, and the final surplus of profits is distributed amongst them in proportion to the amount of their custom. "Under the policy of cheapness," says Holyoake, "the store enters into competition with the tradesman, and is a continual irritation to him; whereas stores which keep to the average price benefit the shopkeeper, who can obtain better prices for his commodities, since no customer can say he 'can get things cheaper at the co-operative store.'"

One of the great objects which Holyoake and other prominent leaders of the co-operative movement had set their hearts upon realising was the establishing of workshops on the labour co-partnership principle.

Participation in profit by labour was, according to Holyoake, the noblest aspiration of the pioneers. The attempt, however, at co-operative production resulted at first in many failures. Rival theories raised conflicts beteeen partisans, and the producers, who had naturally hoped to find a limitless market in the wholesale consumers' stores, were unexpectedly confronted with opposition, and thwarted in their efforts to advance. Co-operative production is without doubt successful at the present time, but some of the early pioneers felt estranged by the lukewarm, or actually hostile, attitude of the stores. One of the rules of the Rochdale Pioneers provided that a fixed percentage of profits should be allotted to education. Not forgetful of this injunction, it is still recommended that 2½ per cent. of profits should form a fund for that purpose. This important service did much to attach social reformers like Holyoake to the co-operative movement.

Amongst many other works, Holyoake wrote a valuable and entertaining book on "Public Speaking and Debate," in which his definitions are remarkably clear and free from pedantry. It is full of wisdom garnered from many platforms, and Holyoake's own characteristics come out in his kindly and generous conception of the laws which should govern controversial contests. He has a strong, simple, and graphic literary style. Terse and racy, he is also sympathetic and sincere.

Holyoake was actively associated with various public movements. He was acting secretary to the British Legion that went out to aid Garibaldi. The passing of the Bill for legalising secular affirmations was largely due to his efforts. He was the last person to be indicted for publishing an unstamped newspaper; the penalties on the 30,000 copies issued would have amounted to £600,000, and he laughingly tells the story in "Bygones" how Mr. Gladstone, then Chancellor of the Exchequer, would be asked to receive the sum in weekly instalments. The repeal of the Act saved him from all further trouble.

A man of tranquil temper, of unflinching courage, singularly just to his opponents, and loyal to his friends and his principles, Holyoake could count among his friends some of the most eminent men and women of his day—Harriet Martineau, George Eliot, Garibaldi, Mazzini, Gladstone, and Herbert Spencer, to name only a few. John Stuart Mill and Professor Fawcett spoke for him on co-operation when he invited them. His services to Canadian and United States settlers won him the praise of Mr. Gladstone and the Canadian Government. His friends subscribed to present him with an annuity in 1876, and he was entertained at a public banquet on his eightieth birthday. Perhaps above all he valued the many signs of the deeply felt honour paid him by the working men for whom he spent the best both of his labour and time. He died on January 15, 1906.

EBENEZER HOWARD
Initiator of the Garden City Movement

Ebenezer Howard, the creator of the first Garden City, and a father of the scheme of Town Planning, was born in London on January 29, 1850, and educated at small schools at Sudbury, Cheshunt, and Ipswich. He began his career in a stockbrokers' and merchants' office. For a short time he was private secretary to Dr. Parker, of the City Temple. When twenty-two years of age, he went out to Nebraska, and "roughed it" on a farm, passing thence to Chicago, where he was a shorthand writer in the Courts. At twenty-six he was back in London again, member of the staff of a well-known firm of shorthand writers. In their employ he reported the debates of Parliament, and the proceedings of Labour and other Commissions on social subjects. He is still a professional shorthand writer, and his livelihood depends in a measure upon the speed at which he can drive a pencil in recording the words of other men. But on his own account his name is honourably known throughout civilisation. When a dinner in his honour was given in March, 1912, telegrams of congratulation reached him from all parts of the world. Even unhappy Poland joined the chorus of felicitation, in a message dated from the first of Polish Garden City societies.

This modest shorthand reporter of other men's speeches has delivered to the world a greater message than any he has recorded from the lips of others, a message the response to which is found in the far-famed Letchworth Garden City, in our Garden Suburbs, and in the Garden Villages which are yet to be. Should that message remain yet uninterpreted to any, its meaning will be found upon pages 1850-52 of the present work. How it came to be delivered is an interesting story. It will be seen from this brief chronicle of his career that all the steps in Mr. Howard's life specially fitted him for some aspect of the work that he was to undertake. There was the

business experience of the office; there was the inspiration derived from close association with Dr. Parker; there was the contact with the actualities of life in its most primitive aspects out in Nebraska; there was the close insight into the griefs and burdens of social life as expounded by its victims and its would-be reformers before the commissions and conferences he helped to report. These varying chapters combined to constitute a harmonious whole; and when Mr. Howard had added a special study of the chief sociological works extant, there remained but the formulation of his own scheme. As he has said, he has taken a leaf out of the book of each type of

EBENEZER HOWARD

reformer, and bound them together by a thread of practicability. For concrete precedents there existed the admirable models of Bourneville and Port Sunlight.

Mr. Howard embodied his views on the best means of fighting overcrowding in our cities and the depopulation of our villages in a book which will probably become historic. He called it "To-Morrow: a Peaceful Path to Real Reform." That was in 1898. He altered it later to "Garden Cities of To-Morrow," and the first of these is the Letchworth Garden City of today. Letchworth is but the beginning of a world-wide movement initiated by one man, and that man without influence, wealth, or prestige. Taken in conjunction with Mr. Norman Angell's campaign against the barbarous illusions of war, this success gives reformers reason to hope.

The difference between Mr. Howard and other reformers who have sought something like the same ends is that, when he has dreamed his dream, he sallies forth with spade in hand to build the dwelling of his visions. Others built upon paper; he has built upon nearly 4000 acres of actual land. They expressed themselves in pleasant aspirations; he expresses himself in spacious houses, to which sweet air and sunlight have access, and in green pleasaunces and the amenities of home and garden. Single-handed he fought for his idea, by pen and word of mouth. His book was the seed; he cultivated the ground upon which it fell. His meetings numbered hundreds. His clear business propositions converted the sceptics, his enthusiasm heartened those who needed no conversion.

Out of his scheme many others have been evolved, the noblest of which is the Town Planning Act. The Garden Suburbs, the Garden Villages, and the Housing Co-Partnership scheme are all the offspring of his plan. He and they who are at work upon these kindred reforms, both in Great Britain and in wider spheres, may very well adopt for their motto that phrase in which one of his disciples, Mrs. Barnett, blessed the founding of the Hampstead Garden Suburb, "making a bit of God's earth beautiful for generations to come."

JOHN HOWARD
The Apostle of Prison Reform

John Howard, an ideal philanthropist, and the apostle of prison reform, was born on September 2, 1726. Authorities are divided as to whether Enfield or Hackney was the place of his birth. Most of his education was obtained under a private tutor. The death of his father left him, at sixteen, in possession of a handsome fortune. He travelled on the Continent, acquired some knowledge of French, and on his return to England settled down in lodgings at Stoke Newington, and married the landlady who had carefully nursed him through a severe illness. Left a widower in 1755, he embarked for Lisbon, which was then suffering from the destructive effects of the great earthquake. His vessel was, however, captured by a French privateer, and he endured the cruel treatment then meted out to prisoners of war. He speedily regained his freedom, married a second

time, and for many years lived on one or other of his country estates, exercising his kindly disposition in ameliorating the condition of the poor. This peaceful life was brought to an end by the loss of his second wife, in the year 1765.

In 1773 Howard accepted the office of High Sheriff of Bedford, and from that time gave free play to the passionate love of humanity that burned steadily within him, and which moved even the sluggish minds of his generation to consider the evils of prison life. Murmurings against the grim travesties of justice had already been heard, and a Committee of the House of Commons had made some inquiries into the state of the gaols as early as 1729. But John Howard determined to devote his fortune and remaining years to investigating and exposing the unspeakable abuses of prison discipline and accommodation that everywhere prevailed.

His first great tour through the English counties was an epoch-making mission. What he saw is almost too shocking to dwell upon. The prisons were generally overcrowded, filthy, ill-ventilated dens, in which felons and debtors, men and women, tried and untried, were herded promiscuously together; where scenes of drunkenness, squalor, gambling, and ghastly immorality were unescapable commonplaces. Even women lay there in irons; and all were subject to the grossest and most rigorous extortions by the gaolors, who, it should be said, were unsalaried, and subsisted on the fees paid them by the prisoners.

In March, 1774, John Howard was cited to appear before the House of Commons, and, after the reception of his report, was thanked by the Speaker for the humanity and zeal that had prompted him to visit the several gaols of the kingdom. The first fruits of his self-devotion appeared in an Act which provided for the liberation of all prisoners against whom the grand juries had failed to find a true bill, and made the wages of gaolers a charge upon the county rates. An Act quickly succeeded this prescribing regulations as to sanitation, cleanliness, medical advice, clothing for naked prisoners, and, as far as possible, the abolition of underground dungeons.

To enhance the value of his recent inquiries, Howard made, in 1775, the first of a series of European tours, having the express object of collecting and publishing first-hand information about the prisons of the Continent. Tactfully and persistently he gained admission to most of the notorious gaols in France, Belgium, and Germany. Into the Bastille he was not allowed to enter. He embodied his observations in a volume which appeared in 1777 on "The State of Prisons in England and Wales, with an Account of some Foreign Prisons." It was packed with statistics, and contained thoughtful proposals for improving the structure and management of English gaols. These disclosures aroused the public conscience, and a Bill was drafted by Sir Wm. Blackstone and Mr. Eden (afterwards Lord Auckland), which laid down the striking principle that the reform of a criminal's character and habits should be the guiding motive in determining the methods of his treatment. Instruction on morals and religion, practice in some form of industry, and a separate cell for every prisoner during the intervals of work were amongst the far-reaching provisions of this new charter for offenders against the law. The Penitentiary Act of 1778 followed, and though opposition sprang up against the "solitary" system, it was in the end adopted everywhere. Though the solitary system has largely been superseded, it was a great advance on the promiscuous common gaol.

The last few years of Howard's life were largely devoted to studying the plague in the hospitals and lazarettos of the Mediterranean seaports. "Should it please God," he said in his last book, "to cut off my life in the prosecution of this design, let not my conduct be uncandidly imputed to rashness or enthusiasm, but to a serious, deliberate conviction that I am pursuing the path of duty." His anticipation was verified. While ministering to a young lady who was suffering from camp fever, he was himself attacked by the disease, and died on January 20, 1790. "Give me no monument," Howard had said, "but lay me quietly in the earth; place a sun-dial over my grave, and let me be forgotten." But his wish was disregarded, and thousands of reverent admirers stood round the spot where they laid him to rest in the village of Dophinovka, four miles away from Kherson, in the South of Russia.

Of delicate health and small stature, Howard was a singularly brave man. His unquenchable energy, aided by practical sagacity, carried him through risks that would have caused stronger men to pause. Burke, in a glowing eulogy of the great philanthropist, describes his journeying as "a voyage of discovery, a circumnavigation of charity." And Bentham finely says of

him, "In the scale of moral desert the labours of the legislator and the writer are as far below his as earth is below heaven. His kingdom was of a better world; he died a martyr after living an apostle."

SAMUEL GRIDLEY HOWE
An Educator Through the Sense of Touch

Samuel Gridley Howe, an eminent pioneer in the education of the blind, and of blind deaf-mutes, was born in Boston, U.S.A., on November 10, 1801. He graduated at Brown University in 1821, and at the Harvard Medical School in 1824. Sympathising with the Greeks in their struggle for independence (1824–7), he joined their army as a surgeon, and undertook to organise the medical staff. Aided by American supplies of clothing, food, and other necessaries, he formed a colony near Corinth, but through attacks of swamp-fever was compelled to leave the country in 1830. His love of humanity led him to Paris and Edinburgh that he might study the best methods for educating the blind. In Scotland, Mr. James Gall, the Scotch printer and publisher, who had improved the blind alphabet by making the types more susceptible to the touch, gave Howe all the information at his disposal, and on his return to Boston he established a printing-press in the Massachusetts Asylum for the Blind. Here he published the Acts of the Apostles in 1834, and the whole of the New Testament in 1836. Mr. Gall used the common Roman alphabet in his types, but changed the curves of the letters into angular forms. Dr. Howe adopted a similar design, but with types of much smaller size; and with these he persevered in printing the whole Bible, finishing the work in 1842. Volumes of every variety followed, and for a considerable period Dr. Howe supplied books for all the institutions in the United States.

In the year that Howe published his Bible for the blind, Charles Dickens made a visit to the Perkins Institute. In his "American Notes" the novelist records the extraordinary story of the blind deaf-mute Laura Bridgman, whom he saw there after she had been under the care and instruction of Dr. Howe for just over four years. The gradual conquest of seemingly insuperable difficulties, the unflagging patience and ingenuity of the teacher, and the amazing responsiveness and quick intelligence of the pupil, combined to demonstrate the value of strictly scientific teaching, reinforced by the exercise of gentle encouragement and praise. To approach the imprisoned mind of a child whose only sense was touch, to set it freely in contact with the myriad interests of the outer world, was the work which Howe resolved to accomplish. He was the first man to succeed. Science had made great strides in the education of deaf-mutes, but as yet nobody had attempted to reach the mind through the avenue of a single sense. It is upon this fact that Howe's fame will for ever stand secure.

JOHN HOWARD VISITING THE SICK IN A PRISON OF THE EIGHTEENTH CENTURY

From Dickens's "Notes" it appears that Howe's celebrated pupil was pitifully frail as a child, and subject to severe fits. When two years old, a fever so prostrated her that another two years passed before she recovered her normal health. In the interval

she had entirely lost sight, hearing, and the sense of smell, while her taste was also impaired. She soon began to explore the house, and to familiarise herself with every object within reach of her restless fingers. She could even sew and knit a little. In 1837, when she was nearly eight, Dr. Howe was permitted to take her to his institution. She had "a large and beautifully shaped head," and when Dickens saw her her face "was radiant with intelligence and pleasure." The first step was the learning of arbitrary signs. Articles such as spoons and keys were given her, and labels embossed with their names were pasted upon them. Then detached labels bearing the same embossed words were handed her, and she could soon link together separate names with their corresponding objects. Afterwards the labels were broken into individual letters and reconstructed. Presently her intellect awoke to the relationship existing between the name and the object. Names would act as messengers from her own to another's mind. On perceiving this truth, her soul shone in her face.

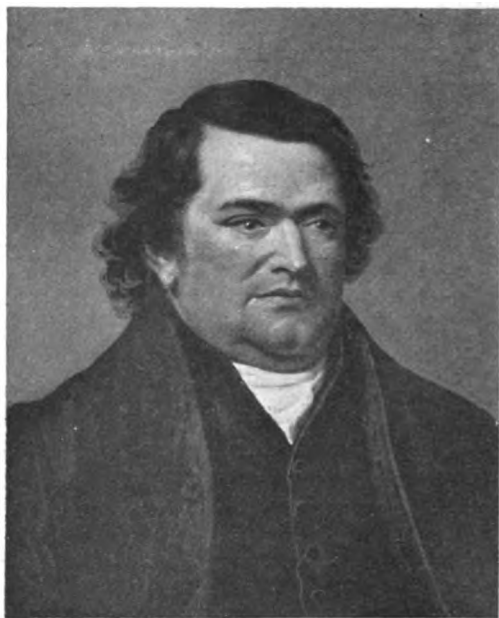
Dr. Howe now procured metal types with letters cast on their ends, and Laura was taught to arrange and read them. Her vocabulary grew apace. She was then instructed in the manual alphabet used by deaf-mutes, and shown that knowledge gained through her fingers could be conveyed to the metal types. So the work went on. In course of time her studies embraced geography, algebra, and history, as well as needlework and household duties. Her handwriting was square and legible, and she was kept busy in answering letters from all parts of the world. She was devout, unceasingly industrious, and happy. Her life closed in 1889, several years after the death of her famous teacher.

Howe and his wife were zealous abolitionists and co-editors of the "Commonwealth." Mrs. Howe is better known as Julia Ward Howe, who wrote the stirring "Battle Hymn of the Republic," which, set to the music of "John Brown's body lies a-mouldering in the grave," was most popular during the American War of 1861-5, and remains one of the world's truly elevated war-songs. Another philanthropic service of Howe was to establish a school for the training of idiots; but it is as the benefactor of the blind that he will be most honoured in remembrance. He died January 9, 1876.

JOSEPH LANCASTER

The School with Religion but Without Creeds

Joseph Lancaster, one of the earliest pioneers of popular education, and co-founder with Dr. Andrew Bell of the "monitorial" system, was born, November 25, 1778, in Kent Street, Southwark. His father was a Chelsea pensioner. The youth was passionately fond of reading, and possessed a precocious gift for preaching. At sixteen he was an usher in a day-school, and two years later he determined to begin teaching on his own account. About this time he attached himself to the Society of Friends, and members of that body became afterwards his most generous, loyal, and patient supporters.

It is necessary to remember, in order rightly to understand the romantic char-

JOSEPH LANCASTER
Photograph by Emery Walker

acter and instant effect of Lancaster's work, that at the close of the eighteenth century the poor were steeped in ignorance, and the condition of the children was especially deplorable. The merest rudiments of learning were denied them, or were with difficulty obtainable. Charity schools for girls, and private adventure schools of a wretched type, existed. In 1781 Robert Raikes inaugurated the Sunday-school movement, and with it came the first glimmerings of a better dawn. Benevolent thinkers were now beginning to discuss education as a possible remedy for a multitude of unbearable social evils.

Joseph Lancaster appeared at the psychological moment. A born teacher, he opened

his first school under the hospitable roof of an affectionate father. A great inrush of scholars ensued; and after repeatedly moving into larger premises he at last built a school in Belvedere Place, Borough Road, Southwark. Here he could receive a thousand children. Without capital, and quite unable to afford adult assistance, he divided his pupils into small groups; intelligent boys, whom he called monitors, were placed over each group, and a chief monitor was appointed to act as superintendent. This was the groundwork of his system.

Lancaster was a man of magnetic personality, and he exercised unbounded sway over the minds of his young teachers, who imitated his methods with surprising celerity. All coercion was forbidden. Quaint forms of punishment were devised, and rewards were lavishly distributed. Disorder is generally the outcome of idleness; and his school motto, "Let every child at every moment have something to do, and a motive for doing it," gave point to his method of securing discipline. Time was economised by the plan of simultaneous reading and spelling. Slates were introduced instead of copy-books, and the youngest children were taught to write in sand, using bits of sticks or their fingers to mark out the letters and words. The system as a whole was ill adapted for stimulating the thinking faculties, being largely mechanical, and with few pretensions to a scientific basis, but it was of incalculable benefit in exciting public opinion and paving the way to a scheme of education on national and State-aided lines. Lancaster had written a tract, in 1803, on "Improvements in Education as it Respects the Industrious Classes of the Community," in which he declared that the education of the poor ought to be a national concern, and pleaded for Christian but unsectarian teaching, "without violating the sanctuary of private religious opinion in any mind."

In the following year Lancaster was commanded to attend upon the old King, George III., at Weymouth. The record of the interview is interesting. After the enthusiast had described his educational methods, his Majesty said, "Lancaster, I highly approve of your system, and it is my wish that every poor child in my dominions should be taught to read the Bible." And when the king expressed his intention of subscribing a hundred pounds yearly towards the realisation of his desire, Lancaster naïvely observed, "Please, thy Majesty, that will be setting thy nobles a good example."

Support had been assured to him for the free education of the poorer scholars, but the additional income which followed in the train of the Royal patronage was not enough to keep pace with Lancaster's reckless expenditure. He had instituted a school for training teachers in 1803, and had entered upon many extravagant enterprises. His natural vanity had led him to ostentatious display. At the same time, he was doing excellent work in spreading a knowledge of his system, and in establishing schools that were conducted on its principles. The skill acquired by his youthful teachers was such that he could leave the Royal Free School, in the Borough Road, and travel throughout England, lecturing and organising, and gathering bright lads from various provincial centres to be trained as future masters in the Lancasterian Institute. In the meantime his debts accumulated, and in 1807 he owed nearly £6500. He was arrested for debt, but liberated through the intervention of two friendly Quakers. In 1808 a committee of wealthy men, with undiminished faith in his system as a vital educational force, relieved him of his pecuniary embarrassments, became his trustees, and founded what has since been known throughout an honourable history as the British and Foreign School Society.

But Lancaster's jealousy and bitterness at the loss of his hitherto unchecked authority tried the forbearance of his kindest friends. The final rupture occurred in 1814. He was soon involved again in heavy private debts, and made a bankrupt. In 1818 he crossed the Atlantic, and the remainder of his life was spent in the States, South America, and Canada. His lectures and teaching renewed his fame for a while, but this gradually waned. He never revisited England. His death, on October 23, 1838, resulted from a street accident,

Lancaster was the originator of providing free meals for necessitous school children. His monitorial or "mutual" system (for which he was partly indebted to Dr. Bell) was the parent of the pupil teacher system; and it was his principle of giving simple, undogmatic religious instruction that was recognised in Mr. Forster's Education Act of 1870. By the famous Cowper-Temple Clause no religious catechism or distinctive denominational tenets could be taught in a School Board school. Lancaster, in short, was the founder of the school that is religious though it is undenominational.

FERDINAND LASSALLE
Originator of German Social Democracy

The "advanced" political section of the German people may be embraced in the term "the Social Democratic Party," and the founder of the movement was a brilliant young Hebrew, Ferdinand Lassalle. He was born at Breslau on April 11, 1825, the son of a wealthy merchant. Educated at the Universities of Breslau and Berlin, Lassalle turned away from the business of his ancestors and became absorbed in ancient culture, modern philosophy, and political economy. Everyone who came in contact with him—and he made the acquaintance of some of the leading literary men of his day—recognised his ability, and expected that his temperamental ardour would carry him far. As a matter of fact, his life lacked concentration on a clearly defined aim; and yet, incidentally, it had far-reaching effects.

FERDINAND LASSALLE

When he was only a youth of one-and-twenty he took up the cause of a German lady whose relations with her husband were unhappy, and fought it through court after court for eight years before a satisfactory issue was arrived at. This absorbed much of his time and energy, and postponed for a dozen years the publication of a book which has become the standard presentation of the philosophy of Heraclitus.

Lassalle, a Republican in theory and a Socialist of the collectivist type, saw in the mild and acquiescent Liberalism of his country the chief barrier to the triumph of his ideas. He therefore became a persistent opponent of the palliative attitude of Liberalism. The time had come, he held, for the establishment of a democracy in which Labour should be the dominant force, and he tried to organise the industrial workers of Germany to this end.

The first step, he saw, was the securing of the suffrage for all, thus giving the workers a controlling power over the State if they cared to use it. In furtherance of his ideas he organised what he called the Universal German Working Men's Association, and secured a strong Labour following, particularly in the south. He also wrote a book, "Capital and Labour," designed to discredit the orthodox view of the relations between capital and labour as defined by the accepted economists of his day, and acquiesced in by his bourgeois Liberal opponents. He refused assent to the theory of wages, which, he contended, leaves the bulk of ordinary workers always on the verge of poverty, and divides the bulk of the profits among the capitalist class. His alternative scheme was a form of co-operative labour by which the workers, with State credit to assist them, should be their own capitalists; and for this purpose he preached control of the State by organised Labour, with a view to placing society on a scientific basis, and ensuring to all a sufficiency and the possibility of attaining a life of culture and lofty social ideals.

Lassalle was an idealist of a very exuberant type, with a fire in his advocacy that won him many adherents, and made it necessary for German statesmen to modify greatly the social conditions of their country. A good deal of the existing State-Socialism of Germany—a real Socialism, though not called by that name—has been indirectly due to the influences which Lassalle created.

The end of this somewhat desultory and wayward propagandist was sad and ignoble. He fell in love, was refused marriage because of the objections of the lady's parents, and, when she accepted another suitor, demanded "satisfaction." On August 31, 1864, he died from wounds received in the duel on which he had so recklessly insisted.

SIR JOHN BENNET LAWES
A Revolutioniser of Agriculture

John Bennet Lawes, the experimenter in modern methods of agriculture, was born at Rothamstead, near St. Albans, on December 28, 1814. His father died when he was a child, leaving him the Rothamstead estate, which has become to all farmers and stock-breeders in the civilised world a

place of famous achievement. As a boy, Lawes had a bent towards chemistry, and he was much disappointed at the education he received at Eton and Oxford. It was a hindrance rather than a help to him. No science of any kind was taught, and he at last left Oxford in disgust without taking a degree. Returning home, he fitted up a room in his house as a chemical laboratory, and threw himself into the kind of work he loved.

He began with researches on drugs, and planted some of his land with plants used for making medicines. It was quite by chance that his thoughts were turned to the chemical problems of agriculture. A visitor happened to remark that the different soils needed different manures, and gave as an example the well-known fact that on some farms bones increase a turnip crop, while on others the same manure is not worth the trouble of digging into the ground.

All Lawes's studies in chemistry then flowered out into the idea that governed the rest of his long life. What had been but a hobby became transformed into an earnest scientific pursuit. Without knowing it, he had been training himself for a work of highest practical importance to mankind. He began by trying the effect of bone manure on his own turnip-fields; and he then brought his chemical knowledge to bear on the matter, and by treating the bones with sulphuric acid produced the first artificial manure that had ever been used. It was so successful that in 1843 he established a factory at Deptford for making phosphate manure from bones; and the profits he derived from this venture enabled him to extend the field of his experiments on his Rothamstead estate.

He engaged as his chemical assistant Sir J. H. Gilbert, set up a laboratory in a barn, and began to revolutionise all the traditional methods of cultivating land and feeding farm stock. Every important kind of crop in our country was grown at the same time under different conditions in separate fields. Wheat, for instance, was sown on well-drained land and badly drained land; different manures were employed in different wheatfields, and the quantity of the manures was varied. One field was left entirely without manure, and, instead of a rotation of crops, wheat was grown on it year after year. A large number of new chemical manures were devised by Lawes and Gilbert, and their effect was clearly ascertained by control experiments on similar crops treated with farmyard refuse, and also left entirely without any kind of fertiliser. What has especially made the Rothamstead experiments extraordinarily illuminating to all farmers is the great length of time in which the conditions of the crops under varying treatment have been studied.

It is now seventy years since the unmanured parts of the land have been sown with wheat and grass and left to flourish or decay. The results are therefore of unparalleled value. No modern piece of agricultural research, however brilliant its outcome, can compare with the Rothamstead experiments. These are the most searching of all investigations into the properties of the soil, and the effect upon them of fertilisers and different systems of cultivation. They extend without a break for about three-quarters of a century, and are the fruit of the labours of two generations of men combining high scientific attainments with a wide and practical knowledge of farming operations. Their value was, indeed, generally perceived in 1855, when a fund was raised by public subscription to build Sir John and his fellow-worker a new laboratory in the place of the barn they were using in their chemical researches. In 1889 he signed a trust deed by which he left £100,000 so that his experiments might be carried on after his death. He died on August 31, 1900, but his work is continued by the Lawes Agricultural Trust.

SIR JOHN BENNET LAWES
By permission of the Royal Agricultural Society

GREAT IN THEORY AS IN INVENTION

LORD KELVIN, WHO SHOWED HOW FAR TRUE KNOWLEDGE SURPASSES BUSINESS EXPERTNESS

CONTINUED FROM 4599 CONTINUED ON 4821

CHEMISTS & PHYSICISTS

JOHANN RUDOLPH GLAUBER

A Man who Made Practical Discoveries While Chasing Wild Ideas

JOHANN RUDOLPH GLAUBER, one of the last of the great alchemists, was born at Carlstadt, in Germany, in 1604. He was one of those strangely credulous creatures whose ingenuity in chemical experiments was far more valuable than the theories on which he worked. First among his discoveries is sulphate of soda, the well-known purge now generally called Glauber's salts. It was by chance that he discovered this valuable chemical. He says that in early manhood he was cured of dyspepsia by a mineral water that he had drunk in Germany. When he afterwards took up chemistry he analysed this water, and found that it owed its curative properties to a special salt, which he named "the admirable salt." It then struck him there was a resemblance between this admirable salt and that which remained at the bottom of his retorts after the preparation of spirits of salt, and from this suggestion he was able to work out his interesting discovery.

Like all alchemists, Glauber attributed extraordinary virtues to the thing he found. He called what was merely an ordinary purgative "the universal salt of philosophers." According to him, it cured nearly all diseases, and changed iron into copper, copper into silver, and silver into gold. By using a dye, Glauber managed, in his old age, to stain his white hair black. He at once jumped to the conclusion that he had lighted on the elixir of perpetual youth. Glauber thought that elements were changed from one to the other by the influence of the stars that penetrated to the depths of the earth. In matters of practice, he fancied he had only to apply a very strong acid to some base metal in order to refine it into silver or gold. What convinced him that he was on the right path was the apparent fact that he succeeded in making real rubies in his furnace. But all that he really did was to give glass a deep red colour by melting gold in a saline flux. He was thus the inventor of artificial gems.

But, wild as were his ideas, Glauber made some remarkable improvements in the instruments of chemical analysis, and brought about some important discoveries. He was probably the first man to notice chlorine, but as he did not follow up his observation it was left to Sir Humphry Davy, hundreds of years afterwards, to make the full discovery. Nitric acid seems to have been another of his discoveries, as also was hydrochloric acid. He worked out the use of nitrates in agriculture, and he was likewise the inventor of small vapour-baths. As he grew old, Glauber became a misanthropic man. Flying from the world, which, far from having any attraction for him, had only caused him, he said, miseries and anguish, he lived in solitude, and occupied himself with philosophy and with writing the books in which he revealed his secret processes in chemistry. Glauber also took an interest in a branch of knowledge almost unknown in his time—political and social economy. In his "Treatise on the Prosperity of Germany" there are interesting ideas in regard to industry and agriculture. Glauber died at Amsterdam in 1668.

STEPHEN GRAY

A Man of the Electrical Dawn

Stephen Gray is one of the greatest and most obscure of English men of science. Although he lived in London in the early Georgian period, when the town was a kind of club in which all men doing remarkable work were known to each other, yet his life is almost completely hidden in darkness. All that is known about him is that towards the end of his life he was a poor Brother of

Charterhouse, who apparently spent most of his time in rubbing a glass tube and letting pieces of string dangle from the gallery of the magnificent Elizabethan chamber of Charterhouse, which is still one of the architectural glories of London. Save for the fact that he contributed papers on his experiments with glass tubes and string to the Royal Society, his name would not have survived.

He seems to have been at the time an old man, soured by disappointment and discontented with himself and the world. Very likely the experimental study of science had always been one of the passions of his life. At any rate, when he failed in the world and crept back to his old school, like Colonel Newcome in Thackeray's story, he was one of the most untiring and prodigious of experimenters. Long after his death, Priestley learnt by tradition that the number of researches he had conducted was amazing—no man had his heart more in his work than this poor Brother of the Charterhouse.

He began some time before 1728 in extending the discoveries made by William Gilbert. He found that hair, silk, linen, wool, paper, leather, wood, parchment, and ox-gut could be made by friction to produce electricity. The next year he spent in trying to electrify metals by rubbing, heating, and hammering them. In this he did not succeed. He found, however, that certain substances, which were then known as "non-electrics," were really conductors of electricity, while the "electrics" owed their peculiar property to the fact that they were non-conductors, and did not allow the electricity generated in them by friction to escape. A glass tube, for instance, was a non-conductor; a piece of hempen string was a conductor. In his great experiment he ascended a balcony, and fastened the string to his glass tube, and tied to the other end of the cord a little ball of ivory. He lowered the ball until it almost touched the ground, and placed close to it some bits of light paper. Then, standing on the balcony, he rubbed the glass tube with a piece of silk, and the electricity flowed from the glass down the string into the ball, and the pieces of paper were electrified and attracted to the ball.

By this simple experiment Gray discovered the electric current. First of all men he set free and directed into channels for the service of mankind the mighty force of electricity. He then tried to carry what he called "the electric virtue" further, by tying a hundred or so yards of string to the beams of a ceiling by means of packthread, so as to make a kind of electric wire running at a fixed distance around the hall. He tied his glass tube to one end of the string, and rubbed it vigorously, expecting to see the little ball at the other end become electrified. But nothing happened. The packthread, as he found out, conducted the electric current away from the string and into the nails in the beams. He already knew that silk was, like glass, a non-conductor. So he ran 765 feet of string through silken loops, and by rubbing his glass tube, and bringing it near the end of the string, produced an electric current that flowed to the ball, 765 feet away.

He also showed that the electric current could be carried in circles as well as in lines, and be communicated from one circle to another. His experiments with electric sparks were not fully published, but they appear to have enabled him to anticipate, in theory at least, Franklin's discovery, for in one of his papers he makes the statement: "Electric fire seems to be of the same nature with that of lightning." It is really astonishing to look back at Gray's papers in the light of modern knowledge, and see how many hints they contain of the largest importance. Using extremely simple means, he managed by persistent experiments to hit on the principle of the electric battery; and there can be but little doubt that had he lived a few years longer he would have anticipated the grand discovery of Volta.

Nothing that Gray accomplished was the result of chance experiments. There was fundamental brain-work behind all his researches. Taking some small and curious fact, he expanded it into a theory, and then used this theory as an instrument for suggesting new researches leading to the discovery of laws. For instance, he noticed that when a glass tube was rubbed in the dark it communicated electric fire to certain small objects. From this he concluded that electricity could be carried, by means of a conducting material, over a great distance; and it was on this theory that he proceeded to the discovery of the electric current. His passion for scientific research lasted to the very end of his life. Even on his death-bed his mind still worked on problems in electricity which he had failed to solve. He asked the secretary to the Royal Society to call upon him, and, fighting against his mortal agony, he mentioned some experiments he had been unable to undertake, and begged that the Fellows of the Royal

Society would carry them out for him. He died on February 25, 1736.

OTTO VON GUERICKE

The Discoverer of the Air-Pump

Otto von Guericke, the maker of the first pneumatic machine and the first electric machine, was born at Magdeburg, in Germany, on October 20, 1602. He studied law at various German universities, learnt mathematics in Holland, and visited France and England. On returning to Magdeburg, he was made senator and, later, burgomaster of his native town. His invention of the air-pump in 1650 was a shining event in the history of modern science. It enabled him to settle the vexed problem of the weight of the atmosphere, and show how completely wrong Aristotle had been in dogmatically deciding that air had no weight. With remarkable ingenuity Guericke made a metal globe, divided into two hemispheres that fitted exactly into each other. By means of his air-pump he emptied this globe of air, and, in the presence of a large concourse of people, he invited anyone to pull it apart. Twenty-five horses were necessary to accomplish this feat, yet Guericke showed that, by turning a little tap at one end of the globe and admitting the air, the two hemispheres could be easily separated by a man. In this striking manner he proved that the pressure of the atmosphere on a vacuum globe was such that twenty-five horses were required to overcome it.

THE FAMOUS EXPERIMENT BY WHICH OTTO VON GUERICKE DEMONSTRATED THE PRESSURE OF THE ATMOSPHERE

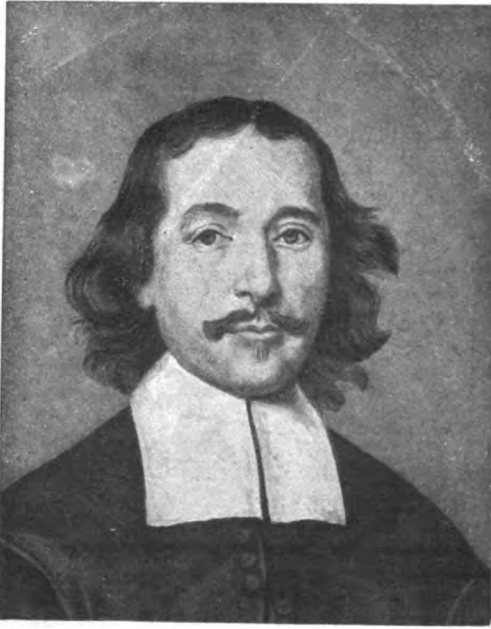
Guericke also used his air-pump to determine the actual weight of the gases of the atmosphere. He did this merely by weighing a globe full of air, and then pumping the air out and weighing the exhausted globe. Some of the people of his town were inclined to regard him as a magician who had dealings with the powers of darknesss. What particularly aroused their suspicion was a weather prophet that always appeared in a recess in the wall of his house whenever there was likely to be a storm. The ingenious burgomaster had built a great barometer filled with water; on the surface of the water floated the figure of the automatic weather prophet. The top of the water-pipe was unclosed, so that the pressure of the atmosphere acted upon the water and drove it higher into the second part, and thus when a storm was approaching the floating figure rose into view.

Still more wonderful was the globe of sulphur that Guericke made by melting sulphur in a glass bowl and breaking the glass away. He mounted the sulphur orb on an axis and whirled it round, rubbing it as it spun. The friction generated electricity, and electric fire was obtained, to the astonishment of all beholders. Guericke's chief discovery in electricity was that when a body was bathed in an electric atmosphere it became charged with an electricity opposite to that of the atmosphere. That is to say, he found that when a piece of paper was attracted to his charged globe of sulphur it was afterwards repelled from the globe. Not until it lost its first charge of electricity by touching some other body could it be attracted by the sulphur globe.

Simple as the burgomaster's experiments now seem, they were the fruit of great labour and ingenuity, and they opened the two roads in chemistry and electricity which

led to these two modern sciences becoming instruments of tremendous power in the hands of later investigators. When Guericke died, in 1686, Boyle had used his air-pump to discover the law of gases, and Stephen Gray was working towards the discovery of the electric current.

HERMANN VON HELMHOLTZ
Explorer of the Eye and Ear

Hermann Ludwig Ferdinand von Helmholtz, one of the greatest men of the nineteenth century, and a supremely great physicist, was born on August 31, 1821, at Potsdam. His father was a schoolmaster, and his mother a descendant of William

OTTO VON GUERICKE

Penn, the founder of Pennsylvania. His father wished him to study languages and literature and follow in his footsteps; but while the boy was apparently studying Latin with his class-mates he was really experimenting under the table with the problems of a telescope. Some of his father's spectacle-glasses and a small lens for use in botany teaching were employed by the lad in making an optical instrument. At seventeen Helmholtz wanted to devote his life to the study of physics, but as his father had only £150 a year on which to bring up a family of four children the lad had to be content with the career of a surgeon in the Prussian army; for a free scientific education was given to youths of promise at the University of Berlin, on condition that they became military surgeons.

At twenty-one Helmholtz distinguished himself by the discovery of nerve-cells in the ganglia. This was the curious result of a severe illness. He had an attack of typhus fever, and while he was being treated in the hospital his small weekly allowance for board was still paid to him. With the money Helmholtz bought a microscope, and with this he discovered the nerve-cells. From 1842 to 1847 he lived at Berlin, having been relieved from his military duties by Humboldt, who quickly recognised his genius. While lecturing on anatomy, he took up the study of animal heat, and began the investigation which enabled him to help in laying the foundations of the great doctrine of the conservation of energy. He also worked out the speed with which a nervous impulse travels along the sensory nerves of man.

In 1851 he was lecturing on the glow of reflected light often seen in the eyes of cats and other animals. He wanted to show his class the nature of the glow, and with this aim he invented an instrument for exploring the interior of the eye through the pupil. This was the famous opthalmoscope, which has proved of great importance even in the study of certain brain and kidney diseases which can be clearly diagnosed from a view of the interior of the eye. When a great eye-surgeon first saw the optic disc and blood-vessels of the living human eye, his face flushed with excitement as he said: "Helmholtz has opened up a new world for us! What is there left to discover?" By means of his instrument the young man of science was able not only to flood with light the obscure diseases and troubles of the eye, but to make contributions of the utmost importance on the problem of vision.

A year or two after his discovery of the interior of the living eye, he took up the study of hearing, and laid the basis of aural science. By giving the first real account of the mechanism of the internal ear, he showed how the sensations of tone were formed. He also investigated in a masterly fashion the cause of the qualities of the human voice. His work on the eye and ear is done so splendidly that it must for generations remain an enduring monument to his genius.

His life was a calm and uneventful one; he worked in long, fierce outbursts of research, and then usually went to Switzerland for a rest. In 1849 he was Professor of Physiology in Königsberg, and in 1855

he occupied the same position at Bonn. Later on he went to Heidelberg, and in 1871 he was called to the Chair of Physics in Berlin. To this professorship was added, in 1887, the post of president of the Physio-technical Institute at Charlottenberg, founded by one of his friends. He had now raised himself to the position of being the first physicist in Germany, and his fame extended throughout the civilised world. The latter part of his life was devoted almost entirely to the investigation of physical problems of an abstruse nature. In spite of the fact that he had never received a training in mathematics, he became one of the great mathematicians of the age. Early in life he played an important part in founding the law of the conservation of energy, working with Joule and Lord Kelvin on the subject. In electricity he took up the study of electrical observations, and, by using the nerve from a frog's leg as a recording instrument, he found that electro-magnetic induction was propagated at the velocity of 314,400 metres a second.

When Clerk Maxwell developed Faraday's ideas into the theory of electric waves propagated through the ether, Helmholtz set his favourite pupil, Heinrich Hertz, the problem of finding these mysterious waves. As it well known, Hertz succeeded, and wireless telegraphy and telephony became possible. Hertz always said that the inspiration came from Helmholtz. Returning from the Chicago Exhibition in 1893, Helmholtz had an attack of giddiness on the steamer, and fell down the cabin stairs. The injuries to his head were severe, and the next year his brain gave way, and he had a stroke of apoplexy. Patiently and calmly he looked forward to the end, and it came on September 8, 1894.

JEAN BAPTISTE VAN HELMONT
Half Scientist, Half Charlatan

Jean Baptiste van Helmont, alchemist and doctor, was born at Brussels in 1577. Belonging to a noble family, he was fairly well off when he had finished his studies in the learning of his time. But after reading Tauler and other mystical writers he decided to renounce all his property and devote himself to medicine, so as to be able to help the very poor. He obtained his degree of doctor at Louvain in 1599, and the next ten years of his life were spent in travelling in Switzerland, Italy, France, and England. An Italian quack he met on his travels inspired him with a passion for alchemy, and for the search after the philosopher's stone. Van Helmont became entirely absorbed in these futile problems, and by marrying an heiress at Antwerp he obtained the funds he needed in his wild experiments. He settled at Vilvorde, near to Brussels; and when a boy was born to him he received the name of Mercury, for the reason that Van Helmont believed he had succeeded in extracting gold from mercury on the day of his son's birth. The secret of prolonging human life was another problem which this alchemist pretended he had solved. Nevertheless, he died himself at sixty-seven, leaving his son to continue his researches.

Van Helmont, it is said, also saw his own soul in the form of a resplendent crystal,

JEAN BAPTISTE VAN HELMONT

and in recompense for all his virtues a good spirit was attached to his person to help him in his work. By this means he was able to discover infallible remedies for all diseases; and one of his disciples says that so surprising were his cures that the Inquisition was startled by them, and was inclined to accuse him of witchcraft and devil-worship. As a matter of fact, Van Helmont's talent in medicine was very small; the last part of his life was afflicted by the death of almost all the members of his family. The enthusiasm he excited had its source in the ardent conviction with which he propagated his doctrines, rather than in the results obtained from the use of his remedies. Mankind generally is easily convinced by persons

with fanatic convictions. There was certainly a good deal of superstition in the confidence that Van Helmont inspired.

But if as a doctor he was of little worth, as a chemist he was a man of genius. No doubt there is much superstition also in his chemical work, for, like the other alchemists of his age, he mingled with his fine experimental researches and important discoveries many odd opinions and ridiculous fancies. But, in spite of all Van Helmont's failings as a man of science, there is one of his achievements which alone suffices to make his name immortal. He has to his credit the strangely delayed discovery of gas.

This discovery is one of the most memorable in the history of modern science. What is still more remarkable is the fact that Helmont recognised the existence of carbonic acid, the first gas he found, not by its striking effects, but by the force of reasoning. He had observed that when coal burnt away it left only an insignificant residue of cinders. From this he concluded that the rest of the coal had disappeared in a volatile form, which he called wild gas. "This spirit that is contained in vessels, but that cannot be reduced to a visible body," said Van Helmont, "I called by a new name —gas." To Van Helmont are also attributed the invention of the water thermometer, the discovery of sulphuric acid, and other well-known chemical substances.

The philosophical doctrines of Van Helmont are a strange mixture of superstition and experimental science. Some of the ideas are very novel, and are animated by a lively feeling of rebellion against the authority of Aristotle and the schoolmen of the Middle Ages. He believed, however, that the ecstacy of the mystic gave a more direct vision of things as they were than did the experiments of the man of science.

HEINRICH RUDOLF HERTZ
The Revealer of Electric Waves

Heinrich Rudolf Hertz, the discoverer of the electric waves, was born at Homburg on February 22, 1857. After his school days were over he thought of becoming an engineer, and at twenty went to Munich to study for his profession. He soon found, however, that his talent for engineering would never be remarkable. Instead of interesting himself in the practical details of his work, he was more concerned about the physical theories on which practical mechanics are based. In less than a year he gave up all thought of becoming an engineer, as it was now clear to him that physical science was something he could work at with joy.

He was resolved this time that he would make his mark, and make it quickly. He devoted the winter of 1877 to reading up great original treatises by the famous physicists of the past. At the same time he attended courses on experimental physics under experienced teachers. The result was that soon after his arrival at Berlin University, in October, 1878, he attracted the attention of the leading experts, and was quickly allotted original research work. One of the Faculties of the university offered a prize for the best solution of a difficult problem in electricity. Hertz won the prize, and became the favourite pupil of Helmholtz. In his next piece of research, undertaken for his doctor's degree, he so surpassed all competitors that an uncommon distinction had to be made for him. From 1880 to 1883 he was assistant to Helmholtz, for whom he carried out some difficult researches in physical science. It was also in 1883 that he seriously began his study of Clerk Maxwell's electro-magnetic theory, in which the existence of electric waves was assumed and their lengths calculated. Various attempts were being made to discover the actual existence of wireless electricity. The waves themselves had been studied in connection with currents sent along a wire, but nobody could substantiate Clerk Maxwell's ideas of free electric waves rippling through the mysterious ether.

Hertz made his famous discovery between 1885 and 1889, when he was Professor of Physics at the Carlsruhe Polytechnic. Clerk Maxwell had shown that, if a conductor is electrically charged or discharged with sufficient suddenness, it must emit electrical waves into the ether, because the charge given to it will not settle down instantly, but will surge to and fro for some time. These surgings produce waves in the ether.

If a wire is handy they will run along it, and may be discerned a long way off. If no wire exists, they will spread out like a sound from a bell or a light from a spark, and their intensity will diminish with the distance. Clerk Maxwell and his followers were able to predict the rate at which these waves would travel. It was known they would go slower in glass and water than in air; that they would curl round sharp edges and be reflected back, somewhat like a ray of light, when they struck against a conductor. It was known how to calculate the length of such waves, and even how to produce them of any length, from a foot to 1000 miles

All this was known, but unverified. Hertz supplied the verification. By means of a special radiator he created a series of waves of different lengths. Then he put a special conductor in the path of the waves, and to his great surprise he found that the mysterious electro-magnetic wave clearly manifested itself in a minute spark. His success was largely due to the fact that he employed an instrument that gave off waves of varying lengths, and picked up the waves by a broken ring of metal which was a poor absorber, but a persistent vibrator. But, having discovered the waves, Hertz did not stop there. By laborious and difficult experiments he ascertained that the previously calculated lengths of the waves were thoroughly borne out by fact. His experiments in the measurement of electro-magnetic waves in free space were his greatest achievement.

He worked out every detail of the theory splendidly, and turned what to most physicists would have been a confusing mass of troublesome facts into a harmonious system of laws. He especially showed that in their susceptibility to reflection, refraction, and polarisation the electric waves were in complete correspondence with the waves of light and heat. Hertz never regarded his discovery as of much practical importance. To him it was merely a confirmation of an abstruse mathematical theory. A very modest man, with a beautifully kind nature, he did not trouble about any possible industrial application of his discovery. He had dropped all interest in that kind of question when he gave up engineering.

In 1889 he was appointed Professor of Physics at Bonn. Here he continued the study of electrical discharges through gases, a subject he had taken up under Helmholtz. He managed to get a mysterious ray of a visible kind out of the glass, but he overlooked the X-ray, which was actually streaming out of the vacuum tube during his experiments, and so Professor Röntgen had something left to discover later.

Hertz died, at thirty-seven, on January 1, 1894. His premature death counts, with that of Carnot and Clifford, among the great losses of science. He was surrounded from his birth with all the influences that go to make an accomplished man of science. He was strong both on the experimental and the mathematical side; and he did not go down to the grave till he had effected an achievement that will keep his name immortal as the founder of a new epoch in experimental physics, and the discoverer of a new force for the use of civilisation.

AUGUST WILHELM VON HOFMANN
The Extractor of Wealth from Waste

August Wilhelm von Hofmann, the father of the coal-tar industries, who vainly tried to establish them in England, was born at Giessen on April 8, 1818. Although Liebig had settled in his native town, and made it the most famous centre of chemical science in Europe, Hofmann was not at first attracted to chemistry. He devoted himself to the study of law and philology, and he then took up mathematics and physics. Though he mixed with the active investigators in

AUGUST WILHELM VON HOFMANN

Liebig's laboratory he did not take any part in their work. But when he at last was attracted to the new science he rapidly distinguished himself, and became the most brilliant of Liebig's pupils. His first piece of research at Giessen, made in 1843, was an investigation of the organic substances contained in coal-gas, and he was the first man to find in coal-tar the now famous aniline that has become of the greatest importance in the manufacture of dyes.

Largely through the influence of the Prince Consort, Hofmann was induced to come to London in 1845, and take the direction of the newly established Royal College of Chemistry, in St. George's Street,

Hanover Square. He did not like the task, for he had heard from Liebig that British manufacturers were, like the rest of their nation, scornful of scientific knowledge. There were only two chemists in Great Britain at the time who were doing first-rate work. The glorious traditions of Dalton and Davy were forgotten, and there was neither public nor private encouragement for chemical science. Moreover, there was no practical school in which a young man could be trained in chemistry.

Hofmann, by his enthusiasm and energy, quickly gathered around him a band of young men many of whom afterwards became famous. Among them were Sir William Henry Perkin, Sir William Crookes, and Sir Frederick Abel. Most of them continued their master's researches on coal-tar, one of the results of which was that Perkin at the age of eighteen discovered his first mauve dye. Hofmann then hoped that the English people, with this proof of the practical value of chemical science before them, would encourage the new scientific industry. In a glowing speech he prophesied that England would soon be using her vast supply of coal-tar in supplying the world with dyes, and making the work of the indigo planters and madder cultivators useless.

But the subscribers to the Royal College of Science, that only needed a few thousand pounds a year to endow our country with industries bringing in annually many millions of pounds, began to withdraw their support, and manufacturers generally took not the slightest interest in applied science. Yet Hofmann at this time, by his enthusiasm and energy and genius, had made the Chemical School famous throughout Europe. His warnings to British manufacturers passed unheeded. The power of money, he said, can do much, but capital, directed by the lights of science, can do much more. Those nations that neglect to call in the aid of science will find their prosperity diminish as neighbouring countries become strengthened and invigorated under the general influence of science.

It especially hurt Hofmann that he found no industrial backing in England; and he came to the conclusion that Englishmen were dulled and stupefied by the wealth arising from the inventions of their forefathers. So, instead of fighting a losing battle in a foreign land, he returned to Germany in 1864, and the next year he was appointed Professor of Chemistry and Director of the Laboratory in Berlin University. Almost from the moment of his departure the higher chemical industries decayed in England. The Chemical College, to which he had devoted nearly twenty of the best years of his life, was slowly starved to death, and the coal-tar manufactures, brought into existence by himself and his English pupils, were allowed to slip into the hands of Germany.

Hofmann was not only a masterly organiser and a matchless teacher, but he exercised a greater and more direct influence upon industrial development than any other chemist. By reason of his early studies of languages he possessed a clear and striking power of expression, and he spoke English with great fluency. No man so capable as he could have been found for the work of training a great school of chemists in our country. Sir William Perkin was merely a boy of fifteen when he came under his influence, and in three years he was a master-chemist, with a great discovery to his credit. Hofmann advised him to continue his research work instead of at once taking up the industrial application of the artificial dye he had found. Had the young English chemist followed this advice it is probable that he would have triumphed over the later German researchers into coal-tar dyes.

Hofmann himself devoted the latter part of his career to the study of amines and ammonium compounds. He was never a skilful manipulator, and, after thinking out a problem, he preferred to set his pupils on the task of experimentation instead of doing the work himself. He thus gave his assistants splendid opportunities of distinguishing themselves; and it is no doubt due to his generous methods of direction that so many of his pupils made their mark in chemical history. He had the power of infecting young men with his own enthusiasm, and of impelling them to exercise their best powers. He died in Berlin on May 5, 1892; and the German Chemical Society, of which he was the founder, erected a memorial to him in Hofmann House. It was opened in 1900 in the most striking manner with an account of the latest victory of German chemical enterprise—the manufacture of synthetical indigo. Happily, Hofmann's influence did not entirely die out in our country; and one of his English pupils recently found a means of recovering from the leaf of the indigo plant a yield of dye that costs less to produce than the synthetic product. So the planters of India may yet defeat the chemists of Germany.

JAMES PRESCOTT JOULE

Who Announced the Immortality of Energy

James Prescott Joule, the discoverer of the law of the conservation of energy, was born at Salford, near Manchester, on December 24, 1818. He came of a family of brewers. Though his father was obliged to retire from brewing on account of ill-health, he always had sufficient wealth to build laboratories for his brilliant son to pursue his scientific researches. Joule, like his father, had a delicate constitution, and for this reason was educated at home, but as John Dalton, the great chemist, was one of his tutors, the boy was inspired with a passion for science at an early age.

Happily, Joule's father took a keen interest in his son's new pursuit; and, though the lad was entirely self-taught in matters of science, he was fortunate in having an abundant store of money to draw on in all his experiments. A room in his father's house was fitted up as a laboratory, and in it began the researches upon electricity and electro-magnetism which brought him fame. At the age of nineteen he invented the electro-magnetic engine with which he made his earliest discoveries. By this time he had practically settled what his life's work was to be. Many persons, unacquainted with the actual work of men of science, would probably regard Joule's early ambition as humble, uninteresting, and insignificant; for all that he was set upon was to improve the various methods of measuring the work done by electrical and mechanical forces. All his life was given up to this laborious and unexciting scientific drudgery. When he married, and went to Switzerland for his honeymoon, he was careful to take with him instruments for measuring the temperature of waterfalls. Lord Kelvin met him there, with his bride on one arm and a thermometer in his other hand.

As Kelvin afterwards said, thinking of Joule as he spoke: "Accurate and minute measurement seems to the non-scientific imagination a less lofty and dignified work than looking for something new. But nearly all the grandest discoveries of science have been but the rewards of accurate measurement and patient, long-continued labour in the minute sifting of numerical results. Faraday's discovery of specific inductive capacity, which inaugurated the new philosophy, tending to discard action at a distance, was the result of minute and accurate measurement of electric forces. Joule's discovery of a thermo-dynamic law, through the regions of electro-chemistry, electro-magnetism, and elasticity of gases, was based on a delicacy of thermometry which seemed impossible to some of the most distinguished chemists of the day."

The fact was, Joule had a vast and splendid idea at the back of his mind, but he was resolved to say nothing about it until he had completely proved it by researches. A Frenchman and a German had rushed into print with a purely theoretic statement of this idea; yet, though Joule had accumulated many facts in support of it, he said nothing, but went on with his experiment. He was chiefly concerned with the measurement of heat. He measured the heat produced by sending water through narrow tubes; he measured the heat disengaged by the chemical combinations in an electric battery, and he had to invent the first really accurate galvometer to do so. He suspended weights from a pulley, and connected the rope with a series of paddle-wheels in a vessel of water, and measured the heat produced in the water by the work of the falling weight. What he particularly wanted to find was what mechanical force is equal to the quantity of heat capable of increasing the temperature of one pound of water by one degree Fahr. In other words, he desired to prove that work was regularly converted into heat according to a fixed scale.

In 1843 he concluded from his experiments that a mechanical force capable of raising 838 pounds to the height of one foot would warm a pound of water one degree. Another essay in measurement gave 770 pounds. In 1846, 781½ pounds was Joule's estimate. In 1848, 772 pounds, and in 1878, 772·55 pounds, was the amount of mechanical force arrived at by Joule. The two latter estimates are practically similar, the slight alteration being due to a certain change in the standard of measurement.

The result of all this exquisite and difficult measurement of the heat-equivalent of a given amount of mechanical force was magnificent. It enabled Joule to establish the law that all the grand agents of Nature are indestructible. The doctrine of the immortality of energy was, in fact, announced by Joule to the British Association in 1847. This was the second time he had pointed out that work resulted in heat, so that no energy was lost, but was merely transformed. On neither occasion were men of science generally interested in his discovery. Some did not see the full meaning

of it; others thought he was wrong. At the meeting of 1847, however, Lord Kelvin happened to be present. He too thought that Joule was wrong, but on going into the matter he found that the tremendous generalisation was well founded. Professor Tait also took up the idea, and, writing in collaboration with Kelvin, brought out the full consequences of Joule's work; and the great law became one of the foundations of modern physics.

In 1862 the British Association appointed Joule to determine the heat-equivalent of a given amount of electro-magnetic force. To get an accurate means of measuring the electric current, Joule invented the electric meter now used for standard measurements by the Board of Trade. Another of his delicate experiments was the measurement of the speed of a hydrogen molecule at the pressure of ordinary air.

In 1872 Joule's health gave way, and he had to leave off all hard work. By living quietly he managed to survive until October 11, 1889. Personally, Joule was one of the most modest of men. He said of himself towards the end of his career, "I believe I have done two or three little things, but nothing to make a fuss about." Yet he is one of the giants of modern knowledge. So modest is true achievement!

LORD KELVIN

Professor, Inventor, Mathematician, and Humbler of Experts

William Thomson, who was created Baron Kelvin of Largs, was born in Belfast on June 24, 1824. His grandfather was a small farmer in the North of Ireland; his father, practically a self-made man, was, at the birth of his illustrious son, a teacher of mathematics in Belfast. When William Thomson was eight years of age, his father accepted the Chair of Mathematics at Glasgow University, and there the future Lord Kelvin matriculated when he was but ten years old! Thompson senior and his son, Lord Kelvin, held professorships simultaneously at Glasgow University, while the elder son, James Thomson, was for sixteen years Professor of Engineering at the same seat of learning. This in itself constitutes a unique family record—three men of two generations, sprung from the same humble Irish home, each occupying a professorial Chair at the same university! James Thomson was himself a man of considerable talent; and the second of Kelvin's three machines, designed conjointly to effect the prediction of the tides for any port, is an application of an invention by that brother.

Kelvin was a phenomenal child; and in his sister's charming domestic chronicle of his "Early Home" we find him at the age of four learning the use of the globes from his father, and at six years attending the parental lectures at the Belfast Academical Institution. Before he was ten he was experimenting with voltaic batteries and electrical machines, and as a matriculated student often carried off two prizes in the Humanity Class. At twelve he won a prize for the translation of Lucian's "Dialogue of the Gods," finishing his student's career at Glasgow as fifth prizeman in the Senior Humanity Class. Proceeding, at seventeen, to Peterhouse, Cambridge, he proved himself one of the rare undergraduates who find twenty-four hours barely sufficient for the day's occupations. He worked with zeal; he played with zest. He rowed; he diverted himself, if not those about him, with his performances on the cornet, and his sister extracts from his diary his diverting record of a tortured tutor's breaking in upon a duet in which Kelvin, leaning on his desk, was playing "Adeste Fideles" while a friend was playing "Logie o' Buchan" at the chimney-piece. In the year of his majority Kelvin graduated from Peterhouse as Second Wrangler and first Smith's Prizeman, a success which gained him a Fellowship at his college.

England had little in those days to teach him of experimental science, and he hurried to Paris to spend a profitable year in the laboratory of Regnault. He was summoned back, at twenty-two, to succeed Dr. Meiklejohn in the Chair of Natural Philosophy at Glasgow. Through all his labours as the greatest physicist of his time, Kelvin, for three-and-fifty years, retained that Chair. Four days a week he lectured twice a morning—from 9 to 10 on experimental physics, from 11 to 12 on mathematical physics.

His lectures were among the curiosities of university life. A man needed to be already an expert physicist to follow him. He talked utterly above the heads of the average student. The man who was absolutely revolutionising physics, who was adding glory to glory for Great Britain in the realms of pure mathematics, who was making life safe at sea by his inventions, bridging the Atlantic with his devices for the electric cable, and incidentally increasing the wealth of the world inestimably—this giant of intellect had the

unruliest, most unappreciative class in his own or any other university.

One of the students who did understand and reverence him says, " To waste the time, energy, and extraordinary original power of a genius like Thomson on such teaching was like using a razor to chop wood, or putting the Prime Minister to holding classes for junior clerks in Downing Street." Yet the classes were not a failure. Now and again the men who, attracted by his fame, flocked from all parts to hear him, would produce from their number the few who appreciated and could follow him. The bulk of them, as soon as they had got their names registered, and he had turned his back to write something on the blackboard, would silently steal away. And the genial luminary, noting the defection, would remark, with a twinkle, that " there seemed a curious gradual diminution of *density* in the upper part of the lecture-room ! "

But he gathered about him a devoted little band of disciples, and by a process of reciprocal assistance they wrought miracles. Those of his students still remaining who remember the old days scoff at the easy path of the present-day student, with his suberb laboratory, his refined apparatus ; they had to do their work with Kelvin in a tumble-down coal-shed ! There was no such thing as a scientific laboratory worthy the name in the 'sixties. That was where they made the world go round—in the lecture-room and the coal-shed adjoining. And in that coal-cellar, with a rattling imp of a boy entering every five minutes to shovel up coal and begrime them and all their instruments with coal-dust, in that sorry laboratory they brought his syphon-recorder to birth. The instrument which brings London within thirty seconds of New York was evolved and perfected in a coal-cellar, just as radium was wrenched from its matrix in a ruinous old shed in Paris.

It is impossible within brief compass to present a summary of Lord Kelvin's contributions, practical and theoretical, to science. His addresses and papers, many of them epochal in importance, number upwards of six hundred, while his inventions were legion. Of these, of course, those in relation to the ocean cable stand foremost. It has been said that his labour in the application of science to practice was more to be esteemed than his work as a pure mathematical thinker, but none of his great inventions could have been achieved but by a mathematician. When he took up the question of the submarine cable, he showed that the then existing theories were erroneous. The cables, he urged, would not stand the current that it was proposed to pour into them. " If you are right, there can never be a submarine cable," his critics answered ; and they let the engineer of the cable company proceed with his big induction coils, five feet in length, and with currents of very high potentiality. They called the invention " the thunder pump." It was worse than that, for the high current simply made sparks leap through the gutta-percha insulation and destroy the hapless cable.

Kelvin, who was merely a director of the cable company, persistently dinned it into his co-directors that the only possible plan was to employ weak currents with very delicate receiving instruments. He was, of course, sneered at as an inexperienced young man who had never erected a mile of telegraph line in his life, but his dogged persistence, coupled with the failures of the " experts," eventually won the day for him. Glasgow already knew and respected him ; at least, the stationmaster did. When Kelvin's experiments were proceeding, again and again he would send down to the station in the evening, saying, " I have gone to White's (the instrument maker's) to hurry on an instrument. The London mail must on no account start tonight until I arrive." And because that stationmaster had faith in the genius of the professor, train after train was delayed. London would be growling at the late arrival of the mails, but those little delays helped to bring the submarine cable into being, for, of course, Kelvin was perfectly successful.

He invented first his mirror galvanometer, an infinitely delicate instrument, mirror and magnet sometimes weighing together only a grain or two. By the method that he condemned, it took thirty hours to get through a message of 150 words from the American President to Queen Victoria ; the " thunder pump " burst the cable. Kelvin began with a minimum of twelve words a minute, and increased presently to twenty per minute. It was afterwards that he created the syphon-recorder in the coal-cellar.

Kelvin loved measurement, and his electric measuring instruments are without rival, especially in regard to electrostatic measurement, perhaps the most difficult of all. His capacity for grasping the minutest of details is reflected in these beautiful instruments. An effect of this faculty appears again in his improved mariners'

compass. The history of that invention is worth remembering as characteristic of the man. Asked to write an account of the compass for a family magazine, he paused in the midst of his series to invent a new compass. "I felt it impossible," he explained to his editor complacently, "to describe compasses which perform their duty ill, or less well than might be." And the improved compasses, used today by every first-class ship in the world, torpedo-boats and torpedo-boat destroyers alone excepted, were the result of that series of articles. Another device of immense importance to navigation was his deep-sea sounding-machine; and his tide-machine is universally employed. These are but outstanding items in a long list of inventions, few of which are not in general use.

It will surprise most people to know that, despite his fecund genius for the creation of refined instruments, Kelvin could not handle them. Says the late Professor Ayrton: "With all his genius, all his power of advising how an experiment should be made, with all his creative originality in suggesting the details of scientific apparatus and methods, Thomson could not make the experiments with his own hands. We all dreaded his touching the apparatus we had set up and adjusted. He was too impulsive, too full of exuberant energy. After the apparatus was broken when he had touched it, he was profoundly sorry." And when, possibly through causes of this sort, his experiments went wrong, he would say: "Faraday's result was so-and-so; mine is just the opposite. But Faraday, with inferior apparatus, *divined* the truth. Remember his result, not what you have just seen me obtain."

Kelvin was Newtonian in his modesty. There was a touching note of humility in his speech to a great and distinguished gathering by which his jubilee at Glasgow University, in 1896, was celebrated. "One word characterises the most strenuous of the efforts for the advancement of science that I have made perseveringly for the last fifty-five years; that word is—failure. I know no more of electric and magnetic force, or of the relation between ether, electricity, and ponderable matter, or of chemical affinity, than I knew and tried to teach my class-students in my first session as professor."

Lord Kelvin, who worked at the revision of his writings up to within three months of the end, died at his Scottish residence, Netherhall, Largs, on December 17, 1907. He was twice married, but had no children. He loved those of everybody else, and there is a thrilling little story of one. At a time when he had just received from Paris several small canisters containing electricity obtained from a thunderstorm, the little child of one of his friends was found to be suffering from a menacing tumour on its tongue. The growth could not be excised by the knife for fear of excessive loss of blood. Kelvin, who had ascertained the degrees of heat derived from his stored lightning, applied, by the merest touch, a wire from one of the canisters, and succeeded instantly where the surgeons had feared to operate. "It was picturesque," said a distinguished man, to whom Kelvin recounted the story—"it was picturesque for Franklin to draw lightning from a cloud into a bottle, but it charms me more to think of a thunderbolt so humanised as to remove a baby's peril by one gentle and painless touch."

ANTOINE LAURENT LAVOISIER

The Godfather of Oxygen and Father of French Chemistry

Antoine Laurent Lavoisier, one of the founders of modern chemistry, was the son of a Parisian lawyer. He was born in the French capital on August 26, 1743. His mother dying when he was five, he was brought up by a rich grandmother, who sent him to the fashionable Collège Mazarin, where he found excellent teachers in all branches of science. His master in chemistry, especially, was a man of genius, and from him Lavoisier acquired the love of chemical research which became the great force of his life. His people wished him to become a lawyer, and he passed his examinations in 1764. but, having taken part in the preparation of a mineralogical altas of France, he decided that science, and not law, was his true avocation.

Unhappily for himself, Lavoisier was a very cautious and prudent man, even in his young days. It struck him he would want much money for his scientific researches, and, having inherited his mother's fortune he employed it in purchasing an interest in the Ferme-Général. This was a company of financiers who farmed the indirect taxes of the country, paying a large sum of money in advance to the State, and collecting themselves the taxes from the people. They were the most hated body of men under the old French Government. The Ferme sent hundreds of persons every year to the galleys for trifling acts of smuggling. Conflicts with its officers took place daily,

and the taxes were most unequally levied. In joining this association soon after he was elected to the Academy of Sciences, Lavoisier took his first step towards the gallows at the same time as he planted his foot on the ladder of fame.

In vain did he try to introduce a finer sense of justice and a better style of management into the Ferme, for, though he was able to remedy many abuses and lighten the burden of impositions, it was too late to wipe from the popular memory the recollections of the exactions and injustices of the past. Indeed, as he rose to a position of power in the company, the hatred of the people seemed to be directed against him. His uprightness, his public services, and the glory of his scientific achievements were disregarded. When the day of reckoning came, he was remembered only as Lavoisier the Fermier-Général.

What brought about the final disaster was a trivial and paltry comedy of vanity. An obscure and ambitious young man tried to make a name for himself at the beginning of. his career by publishing a treatise on fires It was full of the crudest and most ridiculou, speculations on the nature of combustion and the author had the impudence to announce that it had been received with approbation by the Academy of Sciences. Lavoisier was then director of the Academy, and in a few scornful words he publicly remarked that the statement was baseless. The charlatan of science was Marat, the bloodthirsty revolutionist, and in his paper, 'The People's Friend," he attacked the Academy and slandered Lavoisier. The political clubs and revolutionary journals followed the lead Marat gave them. Lavoisier was removed from his official position as director of the Government factory of gunpowder, and in the days of the Terror he was arrested.

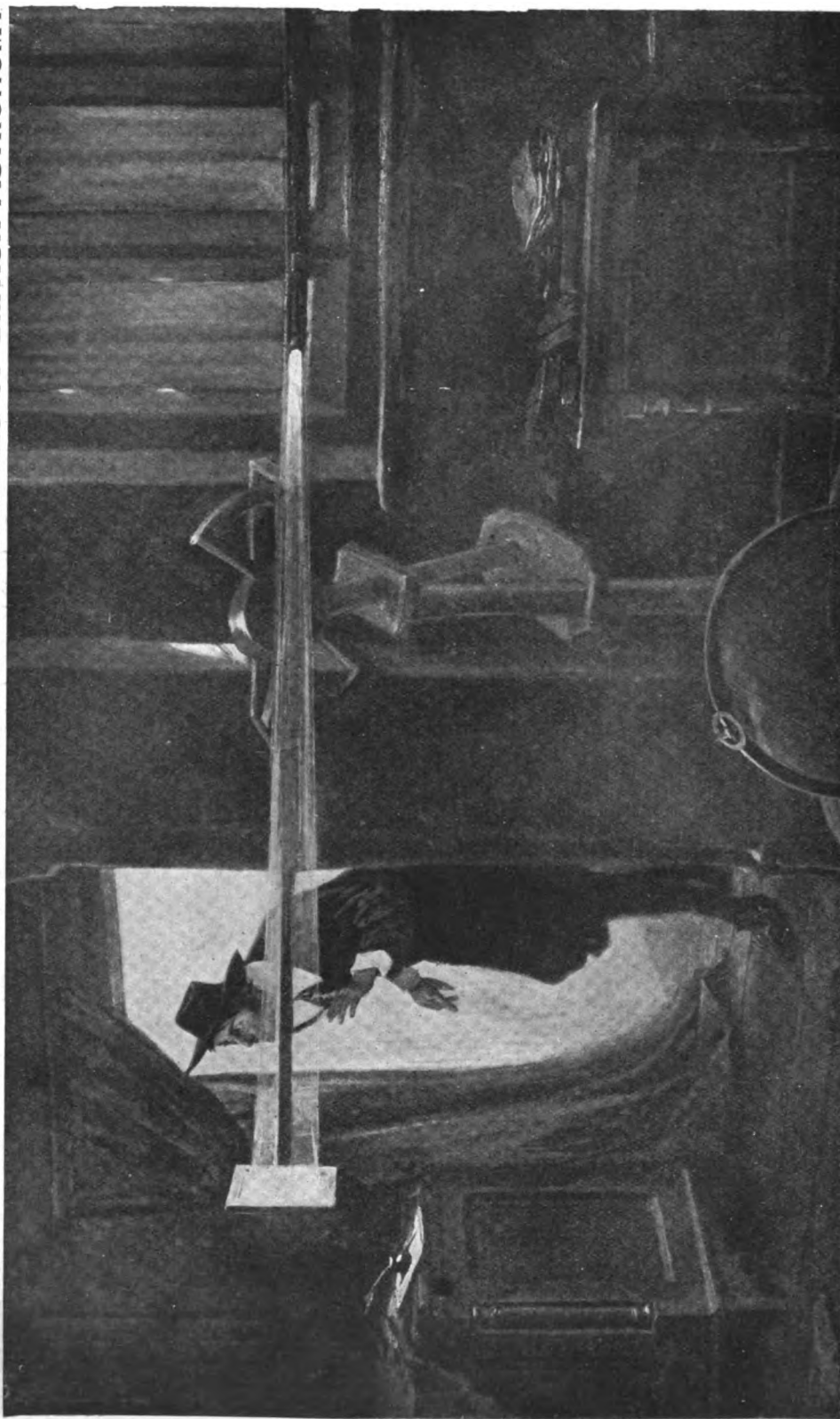
On May 8, 1794, he was brought to trial. Various learned societies presented petitions and memorials extolling the value of his public services, and drawing attention to the fact that the scheme of national instruction then before the Convention was entirely of his creation. All was in vain. The presiding judge pushed the memorial aside with the memorable words: "The Republic has no need of men of science." The sentence of death was ordered to be carried out within twenty-four hours, and on May 9, 1794, Lavoisier was guillotined. Bearing himself with dignity, he met his end with quiet courage, and the crowd that had come to jeer him was awed into silence.

Thus perished, at the age of fifty-one, one of the most remarkable men in the history of science. There was not a scientific body in Europe that failed to give utterance to its sense of shame and sorrow. On the fall of Robespierre the French people became ashamed of their action. A solemn State funeral was decreed in honour of the dead.

Lavoisier's great achievement was the overthrow of the last of the alchemist superstitions that burning was produced by a principle of fire contained in substances. He showed it was the presence of oxygen that brought about combustion, and that the rusting of metal, the burning of wood, and the explosion of gunpowder were one and the same process of oxidation. carried

ANTOINE LAURENT LAVOISIER

out at different speeds. To Lavoisier has been attributed the discovery of oxygen; but though he was not in his lifetime averse to taking the credit for this, it has now been clearly proved that Priestley was the discoverer, and communicated his idea to the Frenchman at a dinner in Paris. Nevertheless, Lavoisier is a greater man than either Priestley or Black. He had a wonderful power of generalisation, together with a remarkable accuracy and breadth of view. With these he was able finally to overthrow the loose opinions regarding combustion and elementary principles which then prevailed, and to establish chemistry as an exact science.

YOUTH, POVERTY, AND SIMPLICITY LAYING THE FOUNDATIONS OF BRITISH ASTRONOMY

JEREMIAH HORROCKS FIRST OBSERVING THE TRANSIT OF VENUS BY CAUSING THE SUN'S DISC TO BE THROWN THROUGH A TUBE INTO A DARK ROOM, SO AS TO SHOW THE PLANET CROSSING THE SUN'S FACE, AS HE HAD FORETOLD. FROM THE PAINTING BY EYRE CROWE IN THE WALKER ART GALLERY

CONTINUED FROM 4635
CONTINUED ON 4839

ASTRONOMERS

SIR WILLIAM HERSCHEL

The Breaker of the Barriers of the Sky

FREDERICK WILLIAM HERSCHEL—he dropped the name Frederick when he settled in England—was born in Hanover on November 15, 1738. He was the fourth of the ten children of Isaac Herschel, an oboist in the band of the Hanoverian Guard. Almost all the children inherited musical gifts; and William, after a short but eagerly pursued education at the garrison school, entered the band at the age of fourteen. At the beginning of the Seven Years' War his parents, finding that the campaign was breaking down his health, smuggled him away to England. For this act of desertion Herschel received a written pardon from George III. in 1782.

In 1757 Herschel landed in England, with a French crown-piece and his musical talent as sole means of support. He earned his living as a music teacher in various towns, began gradually to be known, and in 1766 became a member of the Pump Room orchestra at Bath. The next year he was appointed organist to the new Octagon Chapel, and in 1776 succeeded Lindley as concert director in Bath. By this time he was well on his way to fame and fortune as a musician. In 1771 he had sent for his brother Alexander, and in 1772 for his favourite sister, Caroline, to take part in the concerts.

But music was not by any means sufficient for William Herschel. He had an insatiable desire for knowledge, and the reading of Ferguson's "Astronomy" impelled him to seek for himself the wonders of which it spoke. He could not afford a good telescope, but this did not check his ardour. He determined not only to make his own instrument, but to make one more powerful than any which had yet existed. The house was thrown into utter confusion while the brothers and sister, with the help of a carpenter, set to work with the zest of children. After no fewer than two hundred failures a reflecting telescope was successfully constructed five and a half feet in focal length, and of five inch aperture. From this time Herschel laboured unintermittently to produce a telescope of the highest possible magnifying power. The two hundred failures had given him a mastery in the art of making specula, or telescopic mirrors, in which art he has probably never been equalled. But there have been few with an ardour such as his, which on one occasion never left off polishing a speculum for sixteen hours, lest the removal of his hand should impair its surface. Once, when the conditions of observation were exceptionally favourable, Herschel worked without ceasing for seventy-two hours at his telescope by night and his desk by day, and then slept for twenty-six hours.

Herschel's lifelong passion was to "review the heavens," in the profound sense; to know the celestial bodies, as far as possible, as they really are; to arrive at some conception founded on reality as to the construction of the starry universe. This was the source of his devotion to the perfecting of his instruments, and of the attention he always gave to the highest possible development of his own powers of vision. This fervent love of reality led him, with the instinct of genius, from one discovery to another, so that at the age of eighty-three he was still inspired with the same quest, though at last unable to pursue it.

The making of telescopes went on steadily in every interval of Herschel's numerous musical engagements, and every clear night found him at his telescope surveying the heavens. In 1775 he constructed a seven-foot instrument which already surpassed any existing telescope in the distinctness of its images. Indeed, it is not too much to say that before Herschel's labours distinctness of vision was not even particularly aimed at. After several failures, a magnificent twenty-foot reflector

with a twelve-inch mirror was set up in 1781; yet even this did not satisfy Herschel's hunger for light, and he set to work to construct a thirty-foot instrument. Meanwhile, a fortunate accident had decided his career, and relieved him from the strain of his double profession.

This was the discovery, in 1781, of the planet Uranus—a discovery unprecedented in the records of astronomy. Herschel at once became famous. He was appointed in the following year Astronomer Royal, at a salary of £200, and from this time devoted himself to astronomy alone. Together with his sister Caroline, he moved, first to Datchet, where they lived in a rambling, tumble-down house; then, in 1785, to Clay Hill; and finally, in the following year, to Slough. By making telescopes for sale, Herschel procured the funds necessary for his projected giant forty-foot telescope. His instruments went all over Europe, and for several he received sums of £2000 or £3000 each. But he was fortunately relieved from the necessity of labouring as a mere mechanician by Royal grants for the purpose of constructing the forty-foot instrument. This was begun in 1785, and was set up four years later amid the enthusiasm not only of the Herschels, but of all the scientific world.

The power of this instrument delighted Herschel. At his first view it disclosed to him a new Saturnian satellite, Enceladus; and three weeks later he discovered with it the seventh satellite, Mimas, an object which eludes any but the very highest telescopic power. His delight and triumph appear in his own record. "With the forty-foot instruments the appearance of Sirius announced itself at a great distance, like the dawn of the morning, till this brilliant star at last entered the field, with all the splendour of the rising sun, and forced me to take my eye from that beautiful sight."

The giant reflector was, however, too unwieldy for constant use, and was only employed for special observations. It was with the twenty-foot that Herschel chiefly carried out his projected sweeping of the heavens. This task may be said to have been at once his supreme passion and his life-work. It yielded an incomparably rich harvest of particular discoveries, and of scientific conclusions. But the utimate value of Herschel's labours lay not so much in his many discoveries, nor in the inferences and conjectures which his genius so often drew unerringly from observation, as in the ardour and power which led astronomy, from mere theorising, back to the heavens themselves. At the time when he began his explorations, astronomers were absorbed in attempts to prove or disprove Newton's generalisation, and observed the heavens simply to that end. The stars were receiving almost no study for themselves. Telescopes had never been constructed with any definite idea of securing true and clear images of celestial objects. Sidereal physics and sidereal construction had hardly been conceived of as subjects for practical investigation. But since Herschel led the way the progress of discovery in these directions has been very rapid.

Herschel's own contributions to astronomical knowledge and theory were, however, very considerable. The study of double stars and of nebulæ was first seriously undertaken by him; and even after his death his son possessed the only instrument capable of showing many of the nebulæ which he had discovered. In his "sweeping" observations, which he completed over the whole northern sky, he gathered in a multitude of previously unknown double stars; a catalogue of 269 of these was presented to the Royal Society in 1782, and a second list of 434 in 1784, the large majority being new discoveries. Herschel was the first to perceive the colour harmonies in some of these binaries. His discoveries of nebulæ, of their disposal in space, and of their relations with stars are perhaps even more important. From his early view of nebulæ as separate "universes" consisting of innumerable stars, he was led by his observations to the conclusion that there exists in space a "shining fluid," of which many of these objects are composed. His studies of the sun were very thorough and diligent; he traced out the whole course through which individual sunspots run, and endeavoured to establish some relation between sunspot variations and changes on the earth. He discovered two new Saturnian and two new Jovian satellites, set on foot the modern study of the physical features of Mars, originated the "trade-wind" theory of the belts of Jupiter, and fixed the period of Saturn's rotation. He also instituted a new system of stellar classification in a regular sequence of magnitudes, a method which has been valuable especially in relation to the study of light variation.

Herschel married, in 1788, Mary, widow of Mr. John Pitt; she seems to have been a woman of exceedingly sweet and gentle character. They had one child, John, who rivalled his father's fame as an astronomical

observer. Herschel was knighted in 1816, and in 1821 was elected first president of the Astronomical Society. He died at Slough on August 25, 1822, and was buried at Upton. Above his grave have been placed the words, "Cœlorum perrupit claustra"—He broke through the barriers of the skies.

CAROLINE HERSCHEL

A Great Man's Great Sister

Caroline Herschel was eleven years younger than her "dearest and best" brother William, having been born at Hanover on March 16, 1750. She was a household drudge from a tiny child, and had little tenderness or affection shown her except by William, and, more surreptitiously, by her father. A typical episode recounted in her diary gives a touching picture of the affection of the soldier lad for his six-year-old sister. "My mother, being very busy preparing dinner, had suffered me to go all alone to the parade to meet my father, but I could not find him anywhere, nor anyone whom I knew; so, at last, when nearly frozen to death, I came home and found them all at table. My dear brother William threw down his knife and fork, and ran to welcome, and crouched down to me. The rest were so happy at seeing one another that my absence had never been perceived."

As soon as William was earning a sufficient income in Bath, he sent for Caroline to join him, in 1772. She became a singer when he was concert-director, an untiring assistant when he became an explorer of the heavens. Caroline was at first by no means pleased at the change; the road to success was well open before them in a musical career, but there was nothing to be seen of great promise from the heavens. But her devotion to her brother stifled the revolt of her practical common sense, and nothing could exceed the completeness of that devotion, which was entirely without consciousness of self. Throughout the long hours of the night-watches she was always at her post, recording, assisting in mechanical operations, entering into all that was going on. Without her aid, William Herschel could never have got through anything like the amount of observation which he accomplished. Never, before or since, had astronomer so perfect a companion in his explorations. She was described by Miss Burney as "very little, very gentle, very modest, and very ingenuous; and her manners are those of a person unhackneyed and unawed by the world, yet desirous to meet and return its smiles."

CAROLINE HERSCHEL

SIR WILLIAM HERSCHEL

Although nothing was ever allowed to interrupt for a moment her services as her brother's assistant, Caroline Herschel found time during his absences to sweep the heavens on her own account and became

famous as the discoverer of eight comets. She was a favourite with the Royal princesses, and received attentions from many persons of importance, but all these things left her untouched. Her whole life had but a single purpose—to serve; and her strong heart a single devotion—her brother. His marriage was a great blow to her, but she remained his untiring assistant until his death.

Although she lived for nearly twenty-four years after his death, Caroline's life, in many senses, ceased with his. She retired to Germany and lived honoured but weary at heart, until January 9, 1848, when she died at the age of almost ninety-eight. Her reduction of her brother's catalogue of nebulæ and clusters was an invaluable work, to which she devoted immense labour and patience, and for this she received the gold medal of the Royal Astronomical Society.

JOHN RUSSELL HIND

A Famous Editor of the "Nautical Almanac"

John Russell Hind was born at Nottingham on May 12, 1823. Like so many other astronomers, he early developed a remarkable taste for the subject, but his father insisted upon his studying to be an engineer, and placed him, in 1840, in the office of a civil engineer in London. He was fortunate enough, however, to receive, at the end of the same year, an appointment to the staff of Greenwich Observatory through the influence of Professor Wheatstone. Here he was set to work to record magnetic and meteorological changes. There were, at that time, no self-recording instruments, and Hind had therefore to attend the instruments throughout long night-watches. It was in these solitary hours that he took to calculating the orbits of planets and comets, and was soon known in the Observatory for the remarkable accuracy of his calculations.

Four years later Hind was appointed private astronomer to Mr. Bishop at Regent's Park, and continued to hold this position until his death. At this observatory, which turned out an astonishing amount of good work, he calculated the orbits of many planets and comets, and found ten asteroids between 1847 and 1854.

The first work upon which he was employed by Mr. Bishop was the construction of a chart of the heavens extending to three degrees on each side of the ecliptic. This great labour was begun with the purpose of detecting, if possible, the body which caused the perturbations of Uranus. This was before the calculations of Adams and Leverrier had led to the discovery of Neptune in the summer of 1846. In the course of his observations for the purposes of this chart, Hind discovered some of the asteroids referred to above, and a good many variable stars and several comets.

But it was as director of the "Nautical Almanac" that John Hind really achieved fame. Appointed to this post in 1853, owing to his unrivalled skill in mathematical computation, he brought that valuable publication, on which the safety of navigation so much depends, to the perfection and reputation which it bears at present.

Hind also wrote many papers for the Royal Society, and was author of several popular books on astronomy. Among the latter may be mentioned "The Solar System," "Introduction to Astronomy," and a "Descriptive Treatise on Comets."

Mr. W. E. Plummer, in an obituary notice, thus speaks of Hind's work. "He was emphatically a practical astronomer, and, whether as an observer or in making the mathematical work of others available for practical ends, he had few equals. He knew his capacity very well; he attempted nothing beyond his powers, and few men have made fewer mistakes."

HIPPARCHUS

The Greatest of Ancient Astronomers

About the middle of the third century B.C., a spirit of realism entered into Greek thought, and one of the results of this was that astronomy began to be really a science. That is to say, philosophers were no longer satisfied merely to produce fanciful theories of the universe based upon conjecture rather than upon fact. Observation and calculation became predominant, and hypotheses were relegated to their rightly subordinate place. The systems of Eudoxus and of Aristarchus alike broke down under the test of more careful and detailed observation of the planetary motions. It is the great merit of Hipparchus, the famous predecessor of Ptolemy, that he was more interested to investigate the actual motions and irregularities of the planets than to build up an elaborate theory of the universe.

Hipparchus was born at Nicæa, in Bithynia, nearly at the beginning of the second century before our era. The earliest recorded date of his observations is 161 B.C., and his only book which has come down to us bears the date of 140 B.C. A great part of his life was spent at Rhodes, which was a centre of great intellectual activity.

The system of Hipparchus, which was adopted and elaborated by Ptolemy, was in many points erroneous. None the less, it marked an immense advance, inasmuch as it was really a serious attempt to describe in reasoned form the actually observed motions of the planets. It contains, therefore, a substratum of truth, and has been of inestimable value as a foundation of astronomical science. Hipparchus worked out his system most fully in relation to the sun, and showed that the supposed movements of that body could be accounted for either on the theory of the eccentric circle or on that of the epicycle. This was reasonable enough, for the resultant error was too small to be appreciable with the instruments which astronomers had then at their command. Hipparchus was also the discoverer of the precession of the equinox —that is to say, of the fact that the nodes, or intersections, of the earth's orbit, which was then, of course, regarded as the sun's orbit, with the plane of the equator were not absolutely fixed, but had a slow backward movement.

This ancient astronomer also worked out a theory of the moon and her elusive movements, but with less success than that which attended his explanations of the sun. It is characteristic of Hipparchus that he realised the imperfections of his theory, though he confessed himself unable to remove them. In a similar way, though in a much greater degree, he was to the end dissatisfied with his knowledge of the movements of the planets—so much so that he never elaborated a planetary theory. He corrected the observations which had been made by his predecessors, and was himself a scrupulously accurate observer, but he deliberately left the interpretation of these results to future generations. In this respect, as in so many others, we can see that his views of human knowledge, and of the celestial system alike, were far more profound than those which were current in his time. Early Greek astronomers had been accustomed to found their theories upon observation of the planets at their moments of opposition only, but Hipparchus, on the contrary, recognised that the movements of these bodies must be sedulously followed throughout their entire orbits. In making thorough observations of this kind, he soon found that neither the epicycle nor the eccentric was capable of explaining planetary motion, and there he was obliged to leave the matter—to Copernicus. In addition to his work on the solar system, Hipparchus is known to have compiled a catalogue of stars, which formed the basis of Ptolemy's later catalogue. Ptolemy, who fixes its date at 129 B.C., did very little more than edit it.

JEREMIAH HORROCKS

A Young Intuitive Astronomer

Jeremiah Horrocks was the first astronomer of note who fully accepted the great results of Kepler's work. Indeed, Miss Clerke well says of him that his genius was akin and not inferior to that of Kepler. Yet this amazing youth did not live beyond the age of twenty-three years. Born near Liverpool somewhere in the period 1617-19, the son of a small farmer, Horrocks had to struggle against poverty all his life, and had no assistance in his scientific study. He entered Emmanuel College, Cambridge, in 1632, but left after three years' residence without taking a degree, and justifiably dissatisfied with the university teaching. He had by this time acquired some reputation as an astronomer, and on leaving college threw himself altogether into the study of Kepler. He was soon convinced that Kepler's figures were not correct, and resolved to supplement the labours of that great mathematician.

Having taken orders, he became a curate at Hoole, a very poor parish near Preston. There he eked out his meagre salary of £40 a year by private coaching, but still continued his astronomical studies, though his equipment was limited to a telescope which he had purchased for half-a-crown. His most notable achievement was to foretell a transit of Venus which had not been expected by Kepler or any other astonomer. It duly took place on November 24, 1639. This was the first recorded observation of a transit of Venus across the sun's disc. From these observations Horrocks was able to obtain a more correct determination of the planet's orbit.

His astronomical labours having been grievously hindered by hard work, ill-health, and poverty, Horrocks resigned his curacy in 1640, and returned to his home at Toxteth, near Liverpool, where he completed his treatise on the transit. He had also done much work in relation to the tides, which he investigated in order to obtain more conclusive proof of the earth's rotation. Indeed, he was the first to make a deliberate study of the tides.

Sir Isaac Newton, in his "Principia," generously acknowledged his indebtedness to a work of Horrocks, entitled "The Theory of the Moon," a memoir which shows the

most remarkable anticipation of knowledge which was only clearly ascertained in later years. For example, Horrocks describes the moon as pursuing an orbit in the form of an ellipse with the earth at one focus, and also suggests a variable eccentricity and several other features of the lunar movements. He also made ingenious though erroneous suggestions with regard to the movements of the planets, believing that they were driven round by a force dependent on the sun's rotation.

Horrocks died on January 3, 1641, having accomplished in this brief life of twenty-three years, with little leisure and no means, most remarkable steps forward in the science of astronomy. It has been suggested, not without reason, that if he had lived he might have become the greatest astronomer whom the world has ever produced.

SIR WILLIAM HUGGINS
The Pioneer of Astro-Physics

Sir William Huggins, the great pioneer in the science of astro-physics, was born in London on February 7, 1824. The son of a City linendraper, he was educated for two years at the City of London School, and from 1839 by private tutors at home. His education was of the usual literary kind, but his own inclination was always towards science. His earliest fancy was the microscope, and from 1852 he was a member of the Royal Microscopic Society. While he was still a young man, after a brief commercial career, Sir William Huggins happily succeeded to a private fortune, and thenceforward his sole interest was astronomy. As early as 1854 we find him a member of the Astronomical Society; and by the spring of 1856 he was fully equipped with an observatory of his own, fitted with an equatorial telescope of five-inch aperture and other instruments. This observatory was built in his garden at Tulse Hill, where he lived and worked until his death.

After becoming an expert in the methods of astronomical observation which were familiar at that time, Huggins was attracted, in 1862, by the idea of spectroscopy, owing to a treatise by Kirchhoff, which showed how the dark lines of the solar spectrum could be made to reveal the physical conditions of the sun. Greatly attracted by the new vista of knowledge thus opened up, Sir William Huggins set to work at once to apply the same method to the profoundly suggestive investigation of more distant celestial objects.

Together with Sir William Allen Miller, he adapted the spectroscope to the study of the stars; and with their new instrument they examined the physical constitution of Betelgeux and Aldebaran, and after these of Sirius. Sir William Huggins was the pioneer in this work of searching investigation of the spectra of individual stars, which has revealed entire new worlds of knowledge to the astronomer. For long he worked almost alone in this field. Donati's experiments, though earlier in date, were unsuccessful because his apparatus was unsuitable to the work. Secchi, who was working at stellar spectroscopy at about the same time as Huggins, made no detailed examination of special stars, but swept rapidly through the heavens in search of general results. The careful analytic methods of Huggins, which were quite new to astronomy, resulted in establishing a general similarity, and many profoundly interesting differences, between the sun and the other stars.

The next spectroscopic discovery by Sir William Huggins was of epoch-making importance. He was examining, in August, 1864, a planetary nebula in Draco, and found that it gave a "bright-line" spectrum, thus proving its gaseous nature. Eight other nebulæ which he then examined gave similar results; and in 1868 the Orion nebula was found to yield a spectrum which showed its gaseous constitution, and that it consisted largely of hydrogen, a fact which confirmed the latest belief of Sir William Herschel. The Andromeda nebula, on the contrary, gave a continuous spectrum. These discoveries were of immense importance in clearing away the difficulties in the way of the nebular hypothesis.

Several new stars now came under the test of the spectroscope in the hands of Sir William Huggins. In 1886 he examined the "nova" in Corona Borealis, and in 1891 the brilliant new star in Auriga. He found that these sudden visitants were distinguished from ordinary stars by the presence of certain extremely significant bright lines in their spectra, showing evidence of a conflagration of hydrogen on a stupendous scale. He was thus enabled to pronounce authoritatively on the nature of this phenomenon. "The case is," he says, "that of the casual near approach of two bodies previously possessing considerable velocities in space, such a near approach being far less improbable than an actual or partial collision. Enormous disturbances of a tidal nature would inevitably follow such approach, and produce sufficiently great changes of pressure in the interior of the bodies to cause tremendous eruptions from

within, similar in kind to solar outbursts, but immensely greater."

The most important of all Sir William's discoveries was, however, his adoption of spectroscopic methods for determining stellar motions in the line of sight. The method resulted immediately in most momentous results. Sirius first, and many other brilliant stars afterwards, were found to have extremely rapid movements either towards or away from the earth. Many years will pass before the uses of this method have been exhausted.

Sir William Huggins was also a pioneer in the photography of stellar spectra. After several vain atempts, he succeeded, in 1879, in obtaining photographs of several of these; and in 1882 photographed the solar coronal rays, though his success on this occasion was never repeated.

By all these indefatigable researches, Sir William Huggins ranks among the greatest of astronomers; and he was undoubtedly the founder of the modern science of astrophysics. He was honoured with all kinds of distinctions, at home, on the Continent, and in America. In 1900 he was President of the Royal Society, and for many years President of the Astronomical Society. He was one of twelve chosen as the first members of the Order of Merit in 1902. He died in London on March 12, 1910.

In 1875 Sir William Huggins married Margaret Murray, who was already a keen student of the heavens; she became his sole assistant, and all his papers after their marriage were signed by both. In 1901 Lady Huggins was elected honorary member of the Royal Astronomical Society.

CHRISTIAN HUYGENS

A Great Astronomer who Made Clocks and Telescopes

After the death of Galileo and of Kepler, and before Sir Isaac Newton rose to fame, there is an interval during which Huygens stands out as by far the greatest astronomer of his day. Born at the Hague on April 14, 1629, Christian Huygens de Zuylichem belonged to a wealthy and distinguished family. His father was secretary and adviser to three successive Princes of Orange, and his elder brother, Constantine, succeeded to this responsible office, and came over to England in 1688 with William of Orange.

Christian showed early signs of a very remarkable mind, and his father, as was usual in those days, educated him as rapidly and widely as possible. The boy was instructed in music as well as in the literary subjects which were customary at the period, and at the age of thirteen he was introduced to the construction of machines, an occupation for which he gave evidence of extraordinary ability. At sixteen years he was sent to Leyden to study law, and twelve months later to the University of Breda, where he plunged into mathematics, which always remained his favourite study. His first mathematical essays brought him to the notice of Descartes.

On leaving the university, in 1649, he travelled with the Count of Nassau, and on his return to Holland set to work with enthusiasm on the most abtruse mathematical problems and on the mechanical inventions which are his chief title to fame. He published treatises on the quantities of the parabola and other geometrical figures, and at the same time began to grind and polish lenses for large telescopes, and became, as Herschel afterwards became in a supreme degree, the maker of instruments superior to any others which existed at the time. It was with a twelve-foot telescope of his own handiwork that he not only discovered, in 1656, a sixth satellite of Saturn, known as "Titan," but determined the period of its revolution.

In the following year Huygens succeeded in constructing the first entirely self-regulating clock. Before that time, although the pendulum had been applied to the measurement of time, the lack of a reliable escapement had made a wholly automatic timepiece impossible. The new invention immediately revealed its extraordinary value in astronomical work and in the determination of longitudes, and Huygens drew up a system of "Instructions" for workers who wished to use the clock or chronometer in findng the position of places on land or sea. For all his remaining years he worked at timepieces with great enthusiasm, and brought the art of horology to very considerable development.

It would be impossible even to enumerate the many astronomical discoveries which Huygens initiated, but certainly his most illustrious observations were those by which he first understood the nature of Saturn's rings That planet had been a most baffling puzzle to astronomers ever since the telescope had revealed its apparently triple form, for Saturn changes remarkably in appearance according as the rings are viewed edgewise—when they disappear, except to the most powerful telescopes—or are seen more or less in face. Having by far the best optical instrument of his age, Huygens was able

in 1656, to announce the true relation of Saturn and his rings, though he was not able to separate the ring-system into its component members. In the curious fashion of his generation, he published his discovery of the Saturnian system in an anagram, and at the same time gave to the world, in the same cryptic way, his discovery of Titan. The key to these cryptograms was issued three years later, in a book entitled "The System of Saturn," wherein the whole matter, so far as at that time disclosed, was clearly set forth. The same volume records other important astronomical observations. For example, Huygens describes the bands on Jupiter, the principal markings of Mars, and the Orion nebula. He was able also to define the very significant fact that, even in the largest telescopes, the stars, as distinguished from planets, have no diameter, but are mere points of light without dimensions.

From this discovery he very naturally turned to the determination of the diameters of the several planets, and invented an instrument for the purpose. This, as modified later, became the micrometer which is used in modern observatories. It should be said, however, that a previous worker in the same field, Gascoigne, who was killed at the battle of Marston Moor, in 1644, had constructed a true filar micrometer, but the invention remained unknown for many years afterwards.

Christian Huygens, who had visited France in 1655, returned thither in 1660, and crossed over to England in the following year. He was received in our own land with much enthusiasm, and taught British workmen the art of making and polishing lenses. He became quite enamoured of London, and in 1663 brought over his father to reside here, and the two were accorded a very honourable reception by the Royal Society, of which Huygens became a member. It was a time of general scientific revival, and the French Academy of Sciences, which was being founded about the same time, persuaded Huygens to take part in its direction, offering him at the same time princely remuneration. He acceded to their request, and remained in Paris until the year 1681, when he resigned his position on account of failing health, and returned to his native Netherlands.

To a man of this type, Sir Isaac Newton's "Principia," which he secured in 1689, was, of course, a revelation and a supreme delight. His first impulse was to cross the Channel once more, and get to know the author of the great book; and, having done so, he wrote and published two important works, under the influence of Newton, on light and on weight respectively. But he was now coming near to the end of his time. His last illness began early in 1695, and on July 8 of the same year he died.

Huygen's work was much more copious than can be even suggested by this brief notice. He had few equals in higher mathematics, and some have even placed him on a level with Newton. He was a great expounder of the differential calculus, initiated by Pascal, but still at this time generally unknown. Another important work dealt with the movements resulting from percussion, being an inquiry closely related to the modern science of ballistics. Sir Isaac Newton went out of his way to praise the Dutch scholar's style and methods of mathematical exposition, and paid him the great compliment of confessed imitation. A lighter and more fanciful late work of Huygens is entitled "Cosmotheoros," consisting of conjectures on the physical constitution of distant worlds and their inhabitants. It is an ingenious essay in a kind of speculation which has attracted many astronomers and theologians, and even the modern novelist, but has rather less than no value.

Christian Huygens was never married. Like Newton, and not a few other great mathematicians, he was wholly absorbed in his work. Although forced in some degree into public life, he always desired above all things a peaceful and contemplative seclusion.

JOHANN KEPLER

Discoverer of the Unity of the Solar System

The vast labours of Tycho Brahe, one of the greatest astronomical observers who ever lived, had amassed an enormous wealth of detail, gained by systematic and unwearied observation. But from the speculative point of view, Tycho's work had the single effect of depriving men of all their formerly accepted theories of the construction of the universe. The false ideas had been shattered, and huge materials had been collected towards the building of true science. But Tycho, who rejected the Copernican theory, was not the man to conceive the architectural design which was soon to unite and give meaning to all his observations. Yet the man, though he knew it not, was there in the person of one of his assistants. There has rarely been a happier concurrence of circumstances

than that which brought together the two great minds of Tycho Brahe and Johann Kepler. The former, who has been styled the " King of Astronomers," was a wonderful observer, but Kepler, who possessed one of the greatest mathematical minds of any age, could do little or nothing in that way. It was partly due to physical infirmity. Kepler was a weakly, ill-nourished man, and his eyes were easily fatigued. It is pleasant to remember that Kepler, who struggled through all his years against poverty, anxiety, and ill-health, was generously assisted by the princely Tycho, to whom, in his turn, Kepler always gave most generous honour.

Born at Wiel, in Würtemburg, on December 21, 1571, Johann Kepler was the son of an army officer who was reduced to desperate poverty by the old mistake of becoming surety for a friend. Seeking a way out of his difficulties, the father took to keeping a tavern, and at the age of nine years the immortal Johann was removed from school in order to serve as a potboy. Fortunately, after three years of this unsuitable life, the studious, delicate lad was received into a monastery school, whence he proceeded, in 1589, to the University of Tübingen. Here he studied mathematics, and was introduced to the Copernican theory of the solar system. Its truth broke upon his mind like a new life, and henceforth he had no desire so constant or so keen as the enthusiastic devotion to this novel and wonderful vision of the heavens. He graduated honourably, and was appointed, in 1594, to a very poorly paid mathematical position in Styria. Two years later his first work was published, in the form of a very lucid and closely reasoned argument in support of the Copernican theory, which was at that time a quite debatable matter. In this work he attacked the problem of his life—the harmonious unity which, as he was convinced, bound together all the members of the solar system.

It was entitled the " Mysterium Cosmographicum." Kepler sought herein to find a law of relation between the number of the planets, their periods of revolution, and their relative distances from the sun. Having tried in vain to discover a simple ratio, and then a trigonometrical function, which should explain these distances, he conceived a peculiar hypothesis of five regular solid spheres separating the six spheres of the planetary orbits, and worked out this conjecture at great length and with much fantastic reasoning. He was satisfied, so far, with his extravagant theory, but was still not content with the calculations which Copernicus had given with regard to the mean distances and eccentricities of the planets, and desired to obtain more reliable figures in order that he might give a more complete demonstration to his novel system. As everyone knew, the only living man possessed of the necessary observations was the great Tycho Brahe, who had at that time a reputation which it is impossible to over-

JOHANN KEPLER

estimate. To him, therefore, Kepler appealed. He received a most friendly reply, inviting him to come and join Tycho, and make unrestricted use of all his material. In the year 1600, therefore, Kepler became Tycho's guest at the castle of Benatsky, and there began his long and fruitful researches into the problem of the orbit of the planet Mars.

In the early days of 1601 he became Tycho's assistant, and on the death of the great man, in October of the same year, was appointed his successor as imperial mathematician to the Emperor Rudolph at a good salary, which was, however, somewhat difficult to get out of the treasury. The study of Mars, which he had already

begun, occupied Kepler for four years more; but finally, after countless wrong guesses and an enormous amount of labour, the solution was attained. In 1602 he had come to the conclusion that the orbit was oval in form, but soon perceived that this hypothesis did not satisfy all the data which had been observed. In December, 1604, he wrote to his friend David Fabricius, the astronomer, announcing that he had ascertained the orbit to be a perfect ellipse.

This discovery marked a new epoch in astronomy. It was the abandonment of the principle of circular motion, which had previously been taken for granted as universal in all heavenly bodies. From the discovery of this fact, Kepler proceeded with characteristic enthusiasm to the endeavour to account for it. He believed that a constantly acting force was necessary to maintain a constant motion, because the principle of inertia was as yet unrealised. He supposed that this force emanated from the sun, and moved round with the sun in a circular stream, and that the diminishing velocity of the outer planets was due to the weakening of this force with increasing distance from the sun. He explained the elliptical form of planetary orbits as due to magnetism. "The planets," he said, "are magnets, and are driven round by the sun by magnetic force, but the sun alone is alive." The idea of gravity as accounting for the motions of the celestial bodies never occurred to him at all.

Kepler's studies of the orbital movement of Mars revealed, however, his two first "laws," which are of primary importance. They are as follows. First, planets move in ellipses, with the sun in one focus of the ellipse; and, secondly, the radius vector, or the line joining the sun and the planet, sweeps over equal areas in equal times. These laws were published in his second book, which contained the whole statement of his theory of planetary motion, and was called "De Motibus Stellæ Martis." The title, however, gave the credit of the work to Tycho's observations, for it continued, "Ex observationibus G.V. Tychonis Brahe." This illustrious book ranks, with the "De Revolutionibus" of Copernicus and the "Principia" of Newton, above all other astronomical works. Its manuscript was completed in 1607, and the book was published in the year 1609, in which year Galileo discovered the telescope.

Unfortunately for Kepler, the Emperor Rudolph died in 1612, and the imperial astronomer lost all hope of retrieving the arrears of his salary, and of obtaining the additional help which he had asked in order to investigate the motions of the other planets. This misfortune was followed by a series of domestic afflictions. His three children took smallpox, of which only two recovered, and at the same time his wife died of a nervous affection. Greatly disheartened, Kepler resigned his imperial appointment, and went with his two little children to Linz, where he undertook the duties of "provincial mathematician." He fell into great poverty, and was compelled to supplement his meagre salary by the practice of astrology, although he held this superstition in the contempt which it deserved.

At Linz, Kepler set to work on a very ambitious treatise, which was to be called "Hipparchus," but was never completed. He turned from this to a more elementary work, "Epitome Astronomiæ Copernicanæ," which was published in the years 1618 to 1621. This book deals very fully with the movements of the moon, and applies the laws which had been discovered for Mars to the orbits of all the planets.

Kepler's most attractive work is undoubtedly the book "On Celestial Harmonies," published in 1619, and dedicated to King James of England. Herein he completed his theory of cosmic harmony, which had already been foreshadowed in the "Mysterium Cosmographicum." It was in pursuit of this sublime idea that he had sought the assistance of Tycho. The corrected observations which he then obtained failed to supply him with a harmony in the distances of the planets, so he had to seek it, and ultimately found it, in their motions. It is notable that his true scientific faith insisted on harmony, and rejected or abandoned all that was not harmony. The book is full of very fantastic speculations, but Kepler's unerring devotion to the harmony of the universe, and his insatiable thirst to arrive at its source, were responsible for the prodigious discoveries by which he rejuvenated astronomical science and cleansed the Copernican system from the remains of superstitious nonsense from which it had not yet been disentangled. This book on "Celestial Harmonies" promulgated the third of Kepler's laws, "That the square of the time of revolution of each planet is proportional to the cube of its mean distance from the sun."

A less important but even more laborious work was published in 1627. This consisted of new planetary tables, the "Tabulæ

Rudolphinæ," whose compilation had taken up years of arduous calculation. On the title-page of this book Kepler states—and the history of astronomy fully endorses his claim—that its pages constitute "the restoration of astronomy, conceived and carried out by the Phœnix of astronomers, Tycho." It was altogether characteristic of Johann Kepler that he gave all the honour to another, and sought nothing for himself.

Kepler's ideas of the infinity of stars beyond the solar system were not much in advance of those which were at that time generally accepted. He believed that the fixed stars were set in a solid sphere, and that the centre of this sphere was our sun. This starry sphere, or shell, was two German miles in thickness, and the Milky Way was spangled on its inner surface. Within this all-enclosing shell was the "ethereal air," the medium through which the planets move. The comets consisted of condensations of this air, which, impelled by a force from the sun, moved more or less like living creatures through the ether until they became dissolved by the heat of the sun.

Kepler died on November 15, 1630. His labours and his insight had revealed the solar system in all its simplicity, and had for the first time linked together all its members by the law relating their distances to their periods of revolution.

OMAR KHAYYAM

The Poet who Reformed the Calendar

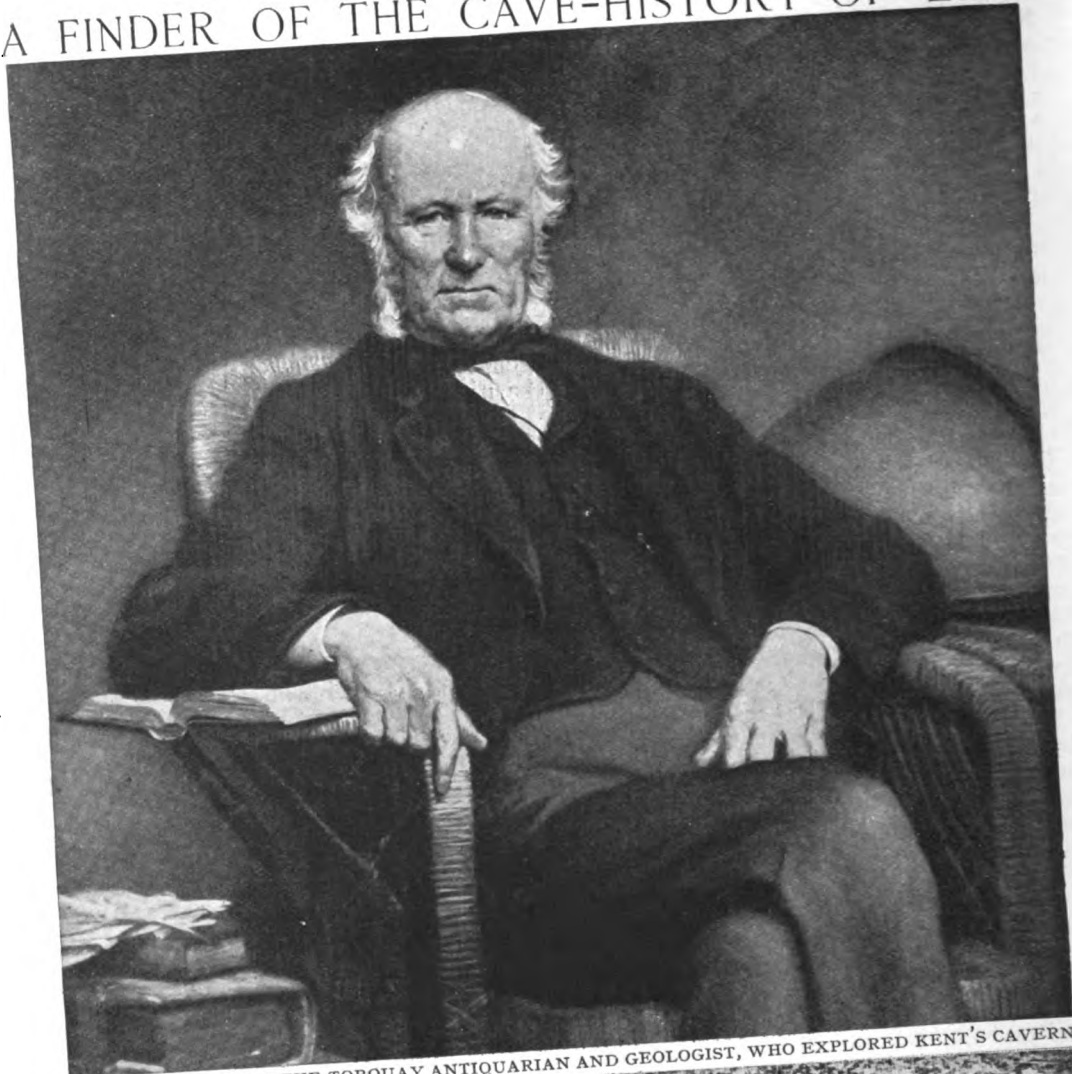
Omar Khayyam is known to all for the philosophic sadness of his haunting verse, but it is not so generally realised that he was probably the ablest astronomer of his age, and held a public position which very nearly corresponded to that of our Astronomer Royal. It is fairly plain that a great astronomer and a great poet did not really, as some of his critics would have us believe, live for the pleasures of wine. No one would set a mere boon companion to work on the reform of the calendar, yet that was Omar's achievement.

In the latter half of the eleventh century of our era the rulers of Persia were served by an extremely able and zealous vizier, whose name was Nizam-ul-Mulk. When the vizier died he left a memoir, or testament, for the guidance of those who should be called, after his own death, to be counsellors of princes, and in these pages he tells the story of Omar. These two, and a third, were drawn together in ardent friendship, as is the way of youth, and they agreed one day that if any of the three should attain to rank and fortune he should afford protection and abundance to the others. In the course of time Nizam-ul-Mulk was advanced, as we have seen, to high office of state, and his old friends were not long in seeking him to claim the fulfilment of the boyish vow. The vizier was as good as his word. One of the friends, Hasan, asked and received a good political appointment, became ungrateful and ambitious, set up on his own account as a robber chieftain, became to all Crusading Europe a name of terror as the "Old Man of the Mountains," and finally achieved an imperishable monument in the world's dictionary, his name being fossilised in the dreadful word "assassin."

The tale of Omar is pleasanter. By early trade a tentmaker, which is the significance of "Khayyam," Omar, in his turn, sought the fortunate vizier. This was his modest request. "The greatest benefit which you can confer on me," he said, "is to let me spend my days in some corner, under the shadow of your good fortune, to spread abroad the value of knowledge, and to intercede for your long life and prosperity."

The vizier ordered him a lavish pension from the treasury, and Omar soon had a vast reputation for learning, and especially for astronomy. Together with seven others, Omar was entrusted with the reform of the calendar, and their labours were so accurate that their computation of time was far superior to that of the Julian calendar. Omar further wrote a work on algebra, of which a French translation exists, and compiled also some very comprehensive astronomical tables.

But it is as a poet that Omar lives. There is in his incomparable verses, incomparably translated, a whimsical, elusive mockery which stands quite alone in literature. His lines, as Fitzgerald has given them to us, take us through some strange region that is not wholly thought nor wholly music, but blends all modes of gaiety and sorrow, belief and unbelief, despair and certitude, sense and spirit. Omar forecasted that his tomb would be in a spot where the wind would cast roses over it. "When I revisited the neighbourhood," says one of his pupils, "I went to his final resting-place, and, lo! it was just outside a garden, and trees laden with fruit stretched their boughs over the garden wall and dropped their flowers upon his tomb, so that the stone was quite hidden."

A FINDER OF THE CAVE-HISTORY OF LIFE

WILLIAM PENGELLY, THE TORQUAY ANTIQUARIAN AND GEOLOGIST, WHO EXPLORED KENT'S CAVERN

THE ENTRANCE TO KENT'S CAVERN, TORQUAY

GEOLOGISTS

WILLIAM PENGELLY

Explorer of Devonian Caves

William Pengelly, born at Looe, on the southern Cornish coast, on January 12, 1812, was the son of a coasting skipper; and after attending an elementary school until the age of twelve he sailed with his father, with a view to following the life of the sea. But, having a keen desire for knowledge, he contrived to educate himself, so that he was able in 1836 to open a school in Torquay. Here his ardour for Nature aroused and organised local interest, and he succeeded in founding a Mechanics' Institute, the Torquay Natural History Society, and, in 1862, the Devonshire Association for the Advancement of Literature, Science, and Art. In later years, having no longer the care of a school, he lectured on geology and archæology in Torquay, and in other towns throughout England. The Baroness Burdett-Coutts took a great interest in his work, and presented his collection of Devonshire fossils to the museum at Oxford.

Pengelly's most valuable contributions to science consisted in his patient and minute explorations of Devonshire deposits and caves, which proved beyond question that the human race existed at a very remote period, when several great mammals, which have long been extinct, roamed over the neighbourhood where he lived. Thus, Brixham Cave, and Kent's Hole, at Torquay, were subjected to a most searching examination, extending, in the latter case, from 1865 to 1880, with the result that stone instruments and weapons, fashioned by human hands, were found, together with a huge accumulation of the bones of the cave-bear, sabre-toothed tiger, cave-lion, woolly rhinoceros, mammoth, and other prehistoric beasts. He also discovered a great deposit of fossil plants at Bovey Tracey. His scientific papers, especially on the antiquity of man, are numerous. Pengelly was admitted a Fellow of the Royal Society in 1863. He died at Torquay, the scene of all his labours, on March 16, 1894.

SIR JOSEPH PRESTWICH

Defender of the Antiquity of Man

Joseph Prestwich was the son of a London wine-merchant who belonged to an old Lancashire family. He was born at Clapham on March 12, 1812. His education was of an extraordinarily varied kind. At five he was sent to a private school, and at thirteen to Paris for two years, having been to two other schools in the meantime. On his return he was for two years at school at Norwood, and for two years at Reading under Richard Valpy. In 1828 he entered University College, London, his taste for geological studies being already strong. But there was little instruction provided at the time in natural science. One course of lectures in mineralogy, included in the teaching of chemistry, was all that was available. Prestwich, however, had the collections in the British Museum near at hand. The following year he entered his father's business, and for many years most of his days were absorbed in commercial duties. His spare time was all given to his favourite science; hours were taken from sleep in order to pursue it, and the necessary books were purchased by overspare living, and both these practices told upon his health in later life.

The first fruits of his studies were two papers contributed to the Geological Society, one on the Gamrie Ichthyolites; the other, and more important, on the coalfield of Coalbrookdale, Shropshire. This second paper was the result of holiday expeditions in 1831 and 1832, and at once established his name as a geologist. Immediately afterwards he set to work with enthusiasm and

perseverance upon the studies which resulted in his most valuable scientific labours—on the Eocene and Pliocene deposits.

In 1842 the father retired from business, and the son took his place. Though for thirty years most of Prestwich's time was taken up in the conduct of the business, he pursued his geological investigations and continued to produce valuable papers. From 1851 to 1888 he published a long series of important memoirs on the Eocene strata of England, and the corresponding strata of the Continent. The Pliocene formations were studied simultaneously, but the conclusions Prestwich had formed were not published until the year 1871.

The study of palæontology was always the chief interest of Prestwich. In 1859, in company with Sir John Evans, he investigated the deposits of the valley of the Somme, and conclusively demonstrated that the flint implements found here, together with fossil mammalia, were the handiwork of men who lived at the same time as the extinct animals. This was an achievement of vast importance, carrying backward, as it did, the life of man to far higher antiquity than had previously been generally understood.

In 1851 Prestwich had published a book dealing with the water-bearing strata in the vicinity of London, and afterwards did great public service in the study of water-supply. In 1869 he was appointed a member of the Metropolitan Water Supply; and, soon after accepting the Chair of Geology at Oxford, he secured for that city a greatly improved service of water. He was also a prominent member of the Royal Coal Commission of 1866.

In 1870 Prestwich was President of the Geological Society, but he craved for rest, and his health suffered from the continual strain of a heavy life. In 1872 he was able to retire from business to his country house near Shoreham, in Kent. Two years later, however, he accepted the professorship of geology at Oxford, and, though over sixty years of age and quite unused to teaching and public speaking, set to work resolutely to acquire these arts. He vacated the Chair in 1888, and retired to the country, devoting himself entirely to scientific investigation and the preparation of several admirable books. The most important of these was his "Geology, Chemical, Physical, and Stratigraphical." He died on June 23, 1896, and was buried at Shoreham.

Prestwich received various honours from the University of Oxford, and was a Fellow of the Royal Society, and other English and foreign learned bodies. He was awarded the Wollaston medal of the Geological Society in 1849 for his work on the Eocene deposits, and the Royal medal of the Royal Society in 1865 for his researches on the antiquity of man. His knighthood dated from 1896. He received the Telford medal of the Institute of Civil Engineers in 1874 for a work "On the geological conditions affecting the construction of a tunnel between England and France." In the same year he published an important work "On Deep-Sea Temperatures," from the results of observations carried out from 1749 to 1868. Sir Joseph Prestwich is a striking examples of what a man engaged in the ordinary business of the world can accomplish out of sheer enthusiasm for science.

ROLLIN D. SALISBURY
An American Leader in Geology

Professor Salisbury, one of the most brilliant of the American geologists who have, in the present generation, created the science of physiography, which deals with the surface features of the earth, was born at Spring Prairie, Wisconsin, on August 17, 1859. He graduated at Beloit College in 1881 and 1884. After acting as tutor for a year be became Professor of Geology at Beloit in 1884, and worked there until he was appointed, in 1891, to the Chair of General and Geographic Geology in the University of Wisconsin. Since 1892 he has occupied the Chair of Geographical Geology in the University of Chicago, and since 1899 has been one of the University deans.

Professor Salisbury has been a member of the United States Geological Survey since 1882, for twelve years as assistant, and since 1894 as head of the glacial division. Since 1891 he has also had the direction of the Pleistocene division for New Jersey. His studies have not been altogether confined to America, for during his professorship at Beloit he spent a year at Heidelberg and other European centres of learning. His most important works, however, deal with features observed in the United States.

In 1909, in an important paper on "The Physical Geography of the Pleistocene," Professor Salisbury made a study of great interest on the effect of altitude on climate, and therefore on geological processes, doing justice, for the first time, to the increased erosion in high altitudes. He shows, however, that the decay of rocks, accelerated by increased altitude, is diminished, on the

other hand, by the lowering of the temperature and by the protection of surfaces with sheets of ice.

In his valuable textbook of "Physiography," published in 1907, Professor Salisbury defines the science which he has made his own: "Physiography has to do primarily with the surface of the lithosphere, and with the relations of air and water to it. Its field is the zone of contact of air and water with land, and of air with water." He distinguishes also between geology and physiography: "Geology has to do with the history of the earth, while physiography has to do only with a late chapter of that history." Professor Salisbury is joint author with Mr. Chamberlin of a valuable work entitled "Geologic Processes."

ADAM SEDGWICK

An Expert in Stratification

Adam Sedgwick was born on March 22, 1785, at Dent, in Yorkshire, where his father was a curate. This little country town, then thriving and unspoiled, remained to the end of his life Sedgwick's supreme love. After many years of absence, he revisited it as an old man, and was chilled by the lack of the old familiar greeting by his Christian name—the new inhabitants used a more ceremonious address, which proved him a stranger in his own country. The figures associated with its antique, picturesque life were always vividly in his memory, and he would often describe them at the many convivial gatherings in which he delighted.

Until the age of sixteen, Sedgwick received his education at Dent Grammar School, of which his father had become head-master. He was then sent to Sedbergh, and in 1804 to Trinity College, Cambridge, which he entered as a sizar. He graduated in 1808 as Fifth Wrangler, and two years later was made a Fellow of his college. He worked very hard at college, tutoring and reading at the same time, and the strain began soon to tell upon his health. In 1813 he had to give up work for two years, but after that interval of rest took up his tutoring again. In 1816 he received ordination.

In 1818 the professorship of geology at Cambridge became vacant, and Sedgwick was elected to fill it, though he knew little, and cared little, about the subject, while the other candidate was an accomplished geologist. Much ill-feeling was aroused by the choice, which was very naturally put down to personal interest, but this charge was certainly unfounded. The choice was determined by the strong character and personal power which, even at that age, were evident in Sedgwick. The young man immediately set to work to acquire first-hand knowledge of his subject, and worked hard at it all his life; and there is little doubt that no one has ever done more for the study of natural science at Cambridge than he was able to do by enthusiastic concentration.

Geological science was at that time very little known or studied in England. The pioneer work of Hutton, William Smith, and others had been developed only by French and German students. The vagueness of the ideas which prevailed in those days may be estimated from the general belief that all fossils were the result of the Mosaic Deluge, and that all geological strata owed their origin to the same Flood. Sedgwick's patient, persevering labours, his untiring services as observer, teacher, and as a courageous advocate of scientific progress, were of inestimable benefit to the advance of the science. His first geological expedition was in Derbyshire. After this he studied the rocks of Devon and Cornwall, and in 1820 read a paper to the Cambridge Philosophical Society. which may be considered as the beginning of his work on the Devonian rocks. He already realised that the theory of a simultaneous origin for all fossils was quite absurd; as, for instance, the fossils which he found in the Plymouth corals were manifestly older than those of the

ADAM SEDGWICK

Limestone, and were, moreover, of a totally different character.

In 1829 Sedgwick travelled with Murchison in the Austrian and Bavarian Alps, making detailed studies of the stratigraphy of the district, and in 1831 they carried out similar investigations in Wales. Their researches were then continued in the Devon and Dartmoor district, until in 1839 they published their classification of the transitional strata between the crystalline schists and the coal-measures. The upper series, examined by Murchison, were called by him "Silurian," and he divided them into Upper and Lower; below these came the series specially studied by Sedgwick, and called by him Cambrian; and a third newly identified system of strata received the name of "Devonian." In order to assure themselves of the real independence of the "Devonian" system, Sedgwick and Murchison in the same year made a journey on the Continent, and succeeded in establishing beyond doubt the existence of a distinct system in Germany and Belgium correponding to the British Devonian. Murchison's further researches on the Palæozoic formations led him to the conclusion that Sedgwick's Cambrian system was not at all distinct, but was a part of the Silurian, and this result he published in 1842. Sedgwick convinced of the accuracy of his classification, and grievously hurt by Murchison's denial of it, set out on more elaborate investigations, and in 1852 produced further results in support of his views. The controversy lasted for years, and in point of fact Sedgwick's theory did not receive official recognition until after his death. The Cambrian system is now recognised as an independent geological system found in all parts of the world, though the limits of the system have been more precisely defined since Sedgwick's day, and have in some respects been modified.

Other important stratigraphical researches undertaken by Sedgwick were those among the older rocks of the Lake District, and on the New Red Sandstone of the North of England. His work in the Lake District was begun in 1822, and occupied a great part of his life. Sir Edward Sabine says of these labours: "Perhaps no district in the world affords an example of one man's researches begun so early, continued so long, and ending so successfully as the Lake District to Sedgwick. To his efforts belongs the honour of the first unrolling of the long series of deposits which constitute the oldest groups of British fossiliferous rocks." Sedgwick was the first to define the relations of that part of the New Red Sandstone series which is now known as "Permian," for he succeeded in distinguishing it clearly from the strata lying below and above it. He always maintained the necessity of a detailed examination of the stratification of a district in order to the reading of its geological history, for a study of the fossil deposits was, he asserted, quite inadequate for this purpose.

Sedgwick's work at Cambridge was invaluable to the study of natural science. He got together a geological collection, and formed a museum worthy of the university, and with much difficulty secured the erection of the necessary building for it. He aroused a keen interest in practical study, and by unwearied effort gave to the study of geology a standing in the university which it had never had before. He took a keen interest in the administrative concerns of the university, was senior proctor in 1827, and held various other responsible offices. From 1834, besides his professorship at Cambridge, he occupied a prebendal stall at Norwich. He continued to lecture until 1870, and died at Cambridge on January 27, 1873.

WILLIAM SMITH

The Father of English Geology

Towards the end of the eighteenth century the science of geology was still in the embryonic stage, and the truth was wrapped in a vast amount of fancy. The transition from this stage to the truly scientific era was largely due to the work of William Smith, who was a pioneer in exact observation, and made short work of random speculation. He was born on March 23, 1769, at Churchill, in Oxfordshire, the son of a farmer, and he had no education beyond that which the village school was able to give. By the age of eighteen he had taught himself enough geometry to obtain a post as assistant to a land surveyor. Being of an observant mind, he gained, in the course of his occupation, an intimate knowledge of the physical features of Oxfordshire, Hampshire, and the districts round Bath and Salisbury. Later he set up on his own account as land surveyor and civil engineer in London, where he lived for many years. There he gained a great reputation as an authority on building-stone, and was, in 1838, consulted with regard to the material for the Houses of Parliament. He died at Northampton on August 28, 1839.

William Smith was a geologist of very varied accomplishments, but his chief work lay in his recognition of the unique importance of fossils in determining the ages of the different English strata. He hit upon the fortunate idea of representing these strata and their relations upon a map of England and Wales; and this map, admirable in itself, had the great interest of being the first geological map ever drawn. His walks throughout the southern counties resulted in maps that appeared at intervals between 1794 and 1824. The entire map which he produced was overcrowded with detail, and he was persuaded to prepare a simpler map of smaller size. This exceedingly useful compilation was published, with explanatory text, in the year 1850.

Many of the names which Smith introduced for the various strata have taken a prominent place in the vocabulary of geology. Mr. Woodward, the historian of geology, says of this work: "There can be no doubt of the supreme importance of William Smith's original map of England and Wales; it was a work of genius, planned and executed single-handed, the product of 'the pursuit of knowledge under difficulties,' and of the application of that knowledge. Above all, it was the first true geological map of England and Wales."

The German geologist Werner had already gone far in the study of the relative ages of the rock strata, basing his work, however, entirely upon an examination of their mineral structure. The novel method of determining their period by the fossils which they contained, initiated by William Smith, proved from the first extremely rich in results. Not long after his death, the formations which he had described for England were found to have their equivalent in many parts of Europe, and to fill in important gaps in Werner's classification.

William Smith also set out upon a most ambitious work entitled "Strata Identified by Organised Fossils," but only four volumes of this were completed. More familiar to students of the present day is a geological section which he prepared, showing the formations along a line from London to Snowdon; this is often to be met with as an illustration in geological textbooks. Smith's work in elucidating the geological structure of England was done with such accuracy that no important alteration has had to be made in his work. This was largely because he confined himself to the investigation of facts, and was never tempted into general speculations. His greatness is due in a large degree to this wise restraint, and he has well been called the Father of English geology.

WILLIAM JOHNSON SOLLAS

A Student of Geology Through the Microscope

William Johnson Sollas was born in Birmingham on May 30, 1849. At an early age he was sent to a private grammar school, and after seven years to the City of London School. Fortunately, chemistry already formed at that early date part of the school curriculum; and in this subject, together with elementary mathematics, he took great delight. After leaving school he entered the Royal School of Mines. The staff at that time included Frankland, Tyndall, Ramsay, and Huxley, and to their stimulating teaching he responded by devoted industry. The teacher to whom he owed most was undoubtedly Huxley, whose lectures, by their style, method, originality, and philosophic spirit, were a liberal education in the widest sense. By Huxley's advice serious attention was also given to modern European languages, especially German. "Without it," this great teacher said, "you cannot hope to become a scientific man."

WILLIAM SOLLAS
Photograph by Hills & Saunders

After obtaining his associateship of the School of Mines, Sollas entered at St. John's College, Cambridge, where he was one of the pupils of the Rev. Professor Bonney. Though much time was spent in the open

air, with geology as an excuse, and much that ought to have been devoted to the recognised course of studies was spent in research, he was able, however, to obtain a first class in the final examination.

On leaving Cambridge, Sollas secured an appointment on the Cambridge University Extension Scheme, and for five years was engaged in lecturing on geology in various important manufacturing towns. This work was excellent training, inasmuch as it brought him into close contact with the outside world.

In 1879 he was appointed Lecturer, and afterwards Professor, of Geology and Zoology in University College, Bristol, and in 1882 he was elected to a Fellowship in his old College of St. John's. Soon after this he left Bristol to accept the Professorship of Geology and Mineralogy in the University of Dublin, and to the duties of this Chair he subsequently added those of Petrologist to the Geological Survey of Ireland.

In 1897 Professor Sollas was appointed to the Professorship of Geology and Palæontology in Oxford, and the students of the science have since shown a remarkable increase. The geological collections have been entirely reorganised and brought up to date, a large sum being spent by the university in advancing this work.

Among Sollas's earliest scientific work may be included a Syllabus of Lectures on Geology (1876), which gave a synthetic view of the subject not to be found in the textbooks of that date. His first special investigations were upon the fossil sponges, a neglected group, of which very little was then known. He succeeded in tracing the relations of several of these obscure forms with their living representatives, and discovered at the same time that the siliceous skeletons of these and other organisms had not infrequently been replaced by carbonate of lime, a result so unexpected that it was at first stoutly denied.

Knowledge of this mineral change led next to the study of flints, which were shown to result from the replacement of limestone such as chalk by silica. The living sponges then engaged his attention, and his account of a particular group (the Tetractinellida) forms one of the monographs of the "Challenger" expedition. His last work on this special subject is an elaborate article on sponges in the last edition of the "Encyclopædia Britannica."

The study of minute bodies, like sponge spicules, led him to devise a means of determining the specific gravity of these and other microscopic objects. This is known as the "diffusion column" method. By its means the specific gravity of a single foraminifora or a single diatom can be ascertained with ease and accuracy in a few minutes. The use of this method has been extended to the study of rocks and organic substances, and even to blood.

In the hope of throwing light on the vexed question of Darwin's theory of coral reefs, he proposed to sink a deep boring with a diamond drill into Tunafuti, a coral atoll in the Pacific Ocean, and was sent out by the Royal Society in charge of an expedition with this object. Though this first attempt failed to bore deep enough, a second, undertaken by Professor Edgeworth Davis, succeeded, and brought up cores from 1000 ft. The results are considered to confirm Darwin's views.

Professor Sollas now became interested in petrography, and showed how new species of igneous rocks may be produced by the admixture of molten material and pre-existing rocks. Such hybrid types were shown to have been formed by the passage of granite into gabbro near Carlingford, in Ireland. Two large volumes on the rocks of Cape Colville Peninsula, New Zealand, are his last contribution to petrology.

The internal structure of crystals is a subject to which he has devoted much time and thought, and he has succeeded in showing how the atomic constitution of a mineral may throw light on its physical properties. He has thus explained the *contraction* which silver iodide undergoes when heated. The flow of plastic solids and very viscous liquids has been another favourite subject, and he has shown by "pitch-glaciers" how to illustrate the flow of ice in glaciers and the flow of igneous rocks as observed in the formation of mountains.

Sollas has written a good deal on palæontological subjects, and has shown by what steps the conversion of some ancestral starfish into a sea-urchin was probably accomplished. He has also invented a new method for the study of fossils, which agrees in principle with that of "thin slices" used in investigating recent organisms. Some remarkable results have been and are now being obtained by this method.

In his address as President to the Geological Society in 1909 he treated of "Time in Relation to Geological Events," and in 1910 on "The Evolution of Man in the Light of Recent Investigations." Of late years he has devoted much attention to the latter subject, and his monograph on the

Gibraltar skull (one of the Neanderthal type) is published in the Transactions of the Royal Society. His last work on prehistoric man, entitled "Ancient Hunters," contains his latest views on the early history of our race. A second edition of this is now in preparation, the first having been exhausted in less than a twelvemonth.

His views on the "Origin of Fresh-Water Faunas," the "Pear-Shaped Earth," "Coral Reefs," and the "Formation of Flints" are published in a collected volume of addresses, under the title of "The Age of the Earth."

Professor Sollas has two daughters, both of whom took Firsts at Newnham, and both are interested in science. The elder has translated into English Suess's work on "The Face of the Earth." and the younger has contributed original investigations to the Transactions of the Royal Society.

HENRY CLIFTON SORBY
The Founder of Petrology

Henry Clifton Sorby, one of the most distinguished of amateur geologists, was born on May 10, 1826, at Woodhouse, near Sheffield. An ancestor of his had been the first Master Cutler, and his grandfather had occupied the same position. A love of scientific study was fostered in him by a tutor who had studied medicine, and who interested him in chemistry and anatomy. It was always a firm belief of Sorby that in order to attain the most fruitful study of science a man must be absolutely free from the anxieties contingent upon earning a living—leisure and peace of mind were, to his view, essential. He was fortunate enough to be himself in easy circumstances, which allowed him to pursue his studies in freedom. He was in comfortable circumstances, and he never married.

Sorby's first great achievement is also his most famous. This was the application of the microscope to the study of rocks. The idea of submitting transparent slices of rock to microscopic examination had been put forward some time before by Nicol, but Sorby seems to have been the first to undertake detailed studies of minerals by this method. In 1851 he published a paper containing his first results, "On the Microscopic Structure of the Calcareous Grit of the Yorkshire Coast," a work which unquestionably initiated the modern science of petrology. In 1858 he published his most famous paper, embodying further results of the method, "On some peculiarities in the microscopical structure of crystals applicable to the determination of the aqueous or igneous origin of minerals and rocks." By a comparison of crystals artificially produced with the natural crystals, Sorby was able to draw reliable conclusions concerning the origin of different rocks. By his careful microscopic examination of crystals also he was able to determine conclusively the aqueous or volcanic origin of various rocks, according to the presence of particles which he found included in their substance. This microscopic method has been of the very first importance to geologists and to mineralogists. In 1862 Sorby, on a visit to the Rhine country, met Zirkel, who was greatly impressed with the novel way of examining rock-slices. That eminent geologist was chiefly responsible for promoting the microscopical method, which was more readily welcomed and advanced by French and German than by English geologists. In the following year Sorby applied a similar method to the study of meteoric iron, employing artificial preparations of the metal in order to determine the origin of meteorites. His investigations elucidated not only the nature of stones falling from the sky, but also produced, in a most unexpected way, results valuable to industry.

From 1879 until within a few years of his death, Sorby spent most of his time and all the summer months on board his yacht, the "Glimpse," which was a very complete floating laboratory. He made a special study of the waters surrounding our coasts, and especially of the drainage system of the Thames. To the end he continued to write scientific papers, though for nearly six years before his death he was in indifferent health. He died on March 9, 1908. Professor Sollas says of his last paper, finished very shortly before his death, "It is distinguished by acuteness of observation, ingenuity in experiment, soundness of judgment, fertility in suggestion, and not least by a constant endeavour to obtain numerical results—the same characteristics, indeed, as are to be found in all his work."

Among his more important papers, besides those already mentioned, are "Slaty Cleavage," 1853, and "On the original nature and subsequent alteration of mica-schist," 1863. Sorby was president of the Geological Society in 1878 and 1879. He was generally beloved, for he was the most unaffected and warm-hearted of men, and kept to the end the freshness and fun of a boy. Dr. Sorby left a substantial part of his fortune for the endowment of a Chair of Geology in the University of Sheffield, which he had generously helped to establish.

EDUARD SUESS
The Greatest Living Physiographer

Professor Eduard Suess, the greatest of living physiographers, was born in London on August 20, 1831, the son of an importer of wool. When, however, the great supplies of Australian wool began to come into this country, the father returned to Prague. Eduard was then only three years old, but he has always retained an affection for London. In 1851 Suess was appointed an assistant in the Imperial Museum, Vienna, and held this post for eleven years, but resigned it in 1862, in order to devote himself entirely to research. From 1857 to 1908 he occupied the Chair of Geology in the University of Vienna. For thirty years he was a member of the Austrian Parliament, where he was able, in many ways, to serve the interests of science.

The work of Professor Suess for the last fifty years has been practically identical with the advance of geology. His great study has been the history of the development of the existing features of the earth's surface, and the geological principles by which these features have been brought into being. The results of his researches are set forth in his great classic, "The Face of the Earth," published in three volumes between 1885 and 1909, and later translated into English by Miss Hertha Sollas.

Professor Suess was one of the first to take a broad scientific view of the modifications of the earth's crust. As early as 1875 his wonderfully suggestive book "The Origin of the Alps" opened up quite a new view of these processes. Von Zittel, the historian of geology, remarks that Suess in that work contested the upheaval of mountains and continents by forces acting vertically upward; he refuted the active participation of eruptive rocks in the origin of mountain-chains, and after a brilliant description of the most important mountain-systems of the earth he demonstrated that any arrangement of those according to geometrical laws was altogether illusory. The principles of mountain-building are then discussed at length, and by the exposition of various types of formation it is shown that, "while the first cause of mountain-making is the secular cooling of the earth's crust, the precise form of a mountain-chain is subject to the modifying conditions introduced by those ancient and resistant crust-blocks" or old continental forms and mountain masses. In "The Face of the Earth," the present conformation of the earth's surface is traced to earlier movements and foldings. The influences of glaciation, earthquakes, vulcanism, and other factors are fully reviewed in their effect on the Face of the Earth.

"According to Suess," says Von Zittel, "ruptures and collapses affecting the whole thickness of the earth's crust, together with tangential folding of the upper horizons, are the forces to which the earth originally owed its surface conformation. There is no such thing as an active or passive emergence of portions of the earth's crust; in the estimation of Suess, the theory of elevation is a great error. Suess is inclined to correlate the grand physical events of the earth's history with those of the development of the organic world, and thinks it possible in this way to erect a natural and universal classification of the formations. For this purpose it is not so much the origin of new mountain-systems that comes into question as the periodic recurrence of those great pelagic transgressions, *i.e.* floods, whose cause of origin until now has not yet been discovered." The book deals with a vast range of phenomena, treated in a most convincing way.

Professor Suess is a geologist of extraordinarily wide achievements. He has done work of great value alike in palæontology and in dynamical geology. His books and papers are far too numerous to be named here, but, besides "The Face of the Earth" and "The Origin of the Alps," mention should be made of his "Palæontological Studies" and "The Ground of the City of Vienna." His studies of the Alps resulted in a renovation of the Vienna water-supply, which, on his advice, was brought from the Alps over a distance of sixty miles.

ABRAHAM GOTTLOB WERNER
The Formation of Rocks in Water

Abraham Gottlob Werner, the scion of a family long connected with the mining industry, was born at Wehran, in Saxony, on September 25, 1749. After a period of work in the mines, he studied mineralogy at Freiberg, one of the chief mining schools, which was at that time the principal centre of geological science. Werner was appointed in 1775 curator of the collection of minerals, and teacher, in the Freiberg School of Mines, and in this position, for over forty years, wielded great influence.

Werner's influence was chiefly that of a teacher. His service to science consisted not so much in discovery as in collating facts already known, and in presenting them in systematic order. By means of

the hundreds of students who came from all parts to hear him, Werner kept in touch with all that was going on in all the chief centres of the science, and, with the genius of the born teacher, inspired his young men with great enthusiasm for science. Where, hitherto, ideas had been vague and confused, Werner insisted on the discipline of exact thought and classification; and his great merit was to introduce into the study of geology and mineralogy a coherence which had before been utterly lacking.

All this was done by the spoken word. Werner would not take the trouble to write, and published only one book, his "Introduction to Geognosy." It is recorded that this dislike of writing and of correspondence increased upon him to such an extent that when he was elected a Foreign Member of the French Academy the letter announcing the honour was neither opened nor answered.

Werner classified the rock-formations into five groups, which he believed to recur in series in each epoch of the geological history of the earth. This classification was based almost entirely on the mineralogical structure of the rocks, organic remains being disregarded. This omission, and the fact that his observations were restricted to a very limited area, marred his results, which were further vitiated by his exclusive devotion to the Neptunian theory. But even these faults had their value, because of the previously chaotic state of geological knowledge. Professor von Zittel remarks that the Wernerian doctrine was all the more attractive as it seemed so simple. "It taught that all the rocks of the crust, like the earth's body itself, had taken origin from aqueous solutions, either as chemical or as mechanical precipitates, while volcanic lavas represented rock-material that had been so precipitated, but had subsequently been melted and ejected."

Because of Werner's vast personal influence, his doctrines maintained their hold for many years, and eventually proved a hindrance to geological progress. This was especially true of his narrow, Neptunist theory, and of his view of basalt as an aqueous deposit, and of volcanic outbreaks as due to the ignition of coal deposits in the crust of the earth. The importance of Werner's personal influence in introducing system and exact methods of study into the sciences of mineralogy and geognosy can hardly, however, be over-estimated, and, under William Smith and his followers, soon fructified in the most valuable results. Werner died at Freiberg, on June 30, 1817.

HORACE BOLINGBROKE WOODWARD

Geology and Water-Supply

Mr. H. B. Woodward, late Assistant-Director on the Geological Survey of England and Wales, was born in London on August 20, 1848. His father, the late Dr. S. P. Woodward, was an official of the British Museum. After four years' work in the library and museum of the Geological Society, Mr. Woodward joined, in 1867, the Geological Survey, and for forty-one years was actively engaged upon its work, chiefly in the field. From 1894 until his retirement, at the end of 1908, he was in charge of the office of the Survey in Jermyn Street, and became Assistant-Director for England and Wales in 1901, having charge of all the field-work. Owing to his wide and practical acquaintance with English geological formations, Mr. Woodward has been much consulted with regard to sites for houses, schemes for municipal water-supply, sewage farms, and other public works.

Mr. Woodward has written many books on geological subjects relating to the work which he did on the Geological Survey. In 1907 he published a most valuable "History of the Geological Society of London," which traces not only the history of the society, but also the history of the science of geology, and vividly introduces many of the great men who have built up the science. Among his earlier works are "The Geology of England and Wales," "Geological Survey Memoirs" on various districts, "The Jurassic Rocks," "Soils and Subsoils," and "The Geological Atlas of Great Britain."

In 1910 Mr. Woodward published his "Geology of the London District," in which the work initiated by Prestwich and Whitaker is carried much further. It is a very comprehensive work, dealing more fully with this subject than has elsewhere been attempted, and is so clear as to be interesting even to those who have known little or nothing of geology. It contains several maps, including an admirable contour-map, giving a very clear idea of the hills, valleys, and streams of the area under consideration, from Rickmansworth in the west to Brentwood in the east, and from Barnet and Enfield in the north to Ewell and Shoreham in the south. The geological formations which underlie London are not easily explored, but several deep borings, especially in recent years, have thrown much light upon their composition. Red and mottled clays, sands, sandstone,

and conglomerates have been found at varying depths; Devonian fossils have been obtained over a thousand feet below the surface by means of a boring in Tottenham Court Road; a great variety of rocks has been found at Richmond; and Silurian strata nearly a thousand feet underground at Cheshunt.

The history of early man in the Thames Basin comes under consideration in a chapter on the Plateau and Valley Gravels and the Terraces along the course of the river; and of special interest is a long list of animals which were coæval with man, but are now extinct or restricted to tropical regions. Mr. Woodward shows that the present diversified features are the result of a great series of changes of earth-movements, erosion and deposition, accompanied by varying conditions of scene, climate, and life, and reveals how the aspect of the country has been modified in later times by the agency of man. He enters fully into the effect which the geological structure has had upon water-supply, and shows how the different strata have yielded materials of economic value.

In "The Geology of Water Supply," published in 1910, Mr. Woodward dealt with the various geological conditions upon which a good water-supply depends, and discusses the methods of prospecting for water. His textbook "The History of Geology," 1911, is of great value. Another work, in 1912, entitled "The Geology of Soils and Substrata," affords an excellent example of the value of scientific research.

KARL ALFRED VON ZITTEL

A Famous Palæontologist

"The most universally accomplished palæontologist of his day," Karl Alfred von Zittel was born at Bahlingen, in Baden, on September 25, 1839. At Heidelberg University, which he entered in 1857, he was early attracted to the study of geology. After graduation, he spent a year in Paris, where he acquired a wide, practical knowledge of the fossils of the Tertiary formations in the districts surrounding that city and elsewhere in France. In 1861 Zittel became an honorary assistant in the Geological Institute of Vienna, and in 1863 was appointed lecturer in the University of Vienna, and a curator of the world-famous Natural History Museum. In 1863 he became professor of mineralogy, geognosy, and palæontology at the Carlsruhe Polytechnic.

Professor Zittel was offered, in 1866, the Chair of Palæontology in the University of Munich. This was really a remarkable honour, for Professor Zittel was only twenty-seven years of age. In 1880 the science of geology was included in the duties of his professorship. Later, in 1890, he was made trustee of the National Geological Collection. By this time Professor Zittel was universally recognised as one of the first geologists of the day. He was appointed, in 1899, President of the Bavarian Academy of Sciences.

Munich was the centre of Zittel's labours, and from that ancient city his work has influenced the whole scientific world. Munich possesses an extremely valuable collection of fossils, which are an unrivalled storehouse of information; and to this collection Professor Zittel himself added many of its greatest treasures.

On October 4, 1903, he was knocked down by the street traffic, and two months afterwards he received a further injury of a similar kind. He died on January 5, 1904.

Professor Zittel published many papers on geological subjects, all of them both conscientious and illuminating. Perhaps his most notable book is the well-known "Handbook of Palæontology," published, in five volumes, at intervals between 1876 and 1893. Of this monumental labour it has been well said that "almost incredible as the task may appear, Professor Zittel entered in turn upon the detailed study of each great zoological group, and made himself so thoroughly master of it and its connected literature that he could write upon it with the ripe knowledge and full authority of an expert—competent to revise the work of his predecessors. He was thus in a position to present an ordered classification of the fossil groups, and to show their affinities more clearly than had ever been done before."

Some of Professor Zittel's most elaborate work has been in connection with fossil sponges. The group had never been properly classified; and indeed, until the latter part of the nineteenth century, classification was almost impossible, owing to the little that was known of living sponges. Zittel and Sollas almost simultaneously took up the study of fossil sponges by microscopic methods, and with great success. In 1899 Zittel published his admirable "History of Geology and Palæontology," of which an English translation by Mrs. Ogilvie-Gordon, a former pupil, appeared in 1901. The progress in every department of geology and palæontology is traced in this able memoir from the earliest observations down to the present day.

BIOLOGISTS

CHRISTIAN HAHNEMANN
A Pioneer of Homeopathy

CHRISTIAN HAHNEMANN was born at Meissen, in Saxony, on April 10, 1755, and studied medicine at Leipsic and Vienna. He took his doctorate in 1779, but was one of those who know, at such a point, that their real studies are only just beginning. He was particularly interested in the use of drugs, and was soon struck by the unsatisfactory character of what passed for knowledge on such subjects. These were the days before experimental pharmacology, and any real knowledge of the properties of drugs scarcely existed. Hahnemann made many experiments upon himself in furtherance of his studies, and the conclusion he reached and formulated in the principle of homœopathy was that "like cures like"—that is to say, the remedy for such and such symptoms is the drug which would produce those symptoms in a healthy person.

Frankly, this celebrated principle of "Similia similibus curantur" is nonsense on the face of it, but Hahnemann sincerely believed in it. His practical belief in a principle so manifestly absurd was made possible by another doctrine—namely, that the real value of drugs can only be obtained from very small doses. So great were the dilutions he finally recommended that not even an atom of the drug could be available for a dose, but very often these infinitesimal doses were attended with success.

If we are to understand Hahnemann, and appreciate his belief in himself, his success, and the opposition which he aroused, we must realise the state of medical practice in his day. Large doses of powerful drugs were habitually given, blood-letting was in regular use, and the arrival of a physician who neither poisoned his patients nor drained their life-blood was evidently full of possibilities. His rivals hated and denounced him, and the chemists were infuriated at the minuteness of the doses he prescribed. He therefore gave his medicines to his patients for nothing, but this was illegal, and thus he was prosecuted in one town after another, even including Leipsic, from which he fled, first to Köthen and finally to Paris.

We see nowadays the true merits and demerits of Hahnemann's system. The principle that "like cures like" is nonsensical, and, in any case, it is of no interest to the modern physician, who is concerned not with symptoms but with causes. Hahnemann knew nothing as to the actual causes of disease; and the work of Pasteur, with all that has flowed from it, renders the controversy between "allopathy" and "homœopathy" entirely jejune. At the present day there is no excuse whatever for the existence of a special sect of homœopathists, who, in fact, practise by the same methods as the so-called "allopaths," and who are fortunately enabled to give powerful drugs when necessary by the modern isolation of active principles, so that the modern homœopath can give more of a drug than was contained in the largest doses against which his master fulminated, but can do so by means of a tiny pilule called "homœopathic."

Hahnemann must not be held responsible for everything done in his name. His protest against drugging, and his practical abandonment of drugs altogether, showed

what Nature could do without them—a much-needed lesson. His advocacy of kindness, and the abolition of forcible and brutal methods of restraint in dealing with the insane, is to his eternal honour, and dates from as far back as 1794; and in his popular volume "The Friend of Health" he appears as a reasonable hygienist and teacher of the laws of sound living far in advance of his age. Hahnemann died in Paris on July 2, 1843.

WILLIAM HARVEY

Discoverer of the Circulation of the Blood

William Harvey was born at Folkestone on April 1, 1578, and was educated at Canterbury and Cambridge. He continued his medical studies in Italy, and took the doctorate in medicine of the University of Padua, as well as at Cambridge. He then began to practise in London, and in 1609 was appointed to the staff of St. Bartholomew's Hospital. A few years later he was appointed to lecture there; and in his first course of lectures, in 1616, he declared his views as to the movements of the heart and what they accomplish.

Within comparatively recent times the notebook of Harvey's lectures has been discovered, and thus we can quote from them the first statement of the circulation of the blood, as follows: "It is plain from the structure of the heart that the blood is passed continuously through the lungs to the aorta, as by the two clacks of a water-bellows to raise water. It is shown by the application of a ligature that the passage of the blood is from the arteries into the veins. Whence it follows that the movement of the blood is constantly in a circle, and is brought about by the beat of the heart. It is a question, therefore, whether this is for the sake of nourishment, or rather for the preservation of the blood and the limbs by the communication of heat, the blood cooled by warming the limbs being in turn warmed by the heart."

This is many years earlier than the great book in which the discovery is not merely stated but established. Meanwhile, Harvey prospered greatly as a practitioner. Bacon was one of his patients, and so was James I. Those were stirring times, and the physician sometimes had to follow the Royal patient to the battlefield. Harvey's absences from the metropolis and its affairs did him no good so far as his reputation was concerned. But in 1628 his epoch-making book appeared, and laid the foundation of modern physiology, with the result that "he fell mightily in his practice; 'twas believed by the vulgar that he was crack-brained, and all the physitians were against his opinion and envyed him."

Harvey began by reviewing the accepted theory that the vital spirits are formed in the heart, to which air passes from the lungs. For nearly two thousand years this had been the established view, but the first-hand student could easily show that, whatever was right, this was certainly wrong. Constructive criticism was not so easy, but Harvey proceeded "to contemplate the motion of the heart and arteries, not only in man, but in all animals that have hearts." His labours were immense, systematic, and successful. From the larger mammals down to slugs, crabs, and flies, he dissected, watched the movements of the heart through a lens, or observed the facts of the circulation by experiments on the living animal. It is clear that without these last experiments the discovery could not have been made.

Our tendency today is to suppose that the discovery was a single thing. We forget that the student had first to show that air does not go to the heart, and is not formed there. Next he had to prove, as he did, that the heart pumps blood into the arteries, and that its action is essentially that of a force-pump, and not a suction-pump, as had been supposed. Then came the final task. The blood which reached the heart, and that which it expelled, had to be accounted for. Whence did it come, and what became of it? The preceding points were satisfactory, and not too novel. "But," he continues, "what remains to be said upon the quantity and source of the blood which thus passes is of a character so novel and unheard-of that I not only fear injury to myself from the envy of a few, but I tremble lest I have mankind at large for my enemies, so much doth wont and custom become a second nature. Doctrine once sown strikes deep its root, and respect for antiquity influences all men." Yet, as he goes on to show, the quantity of blood which passes through the heart is so great that it cannot be accounted for as derived from the food, nor on any other hypothesis than that "the blood circulates, revolves, propelled and then returning from the heart to the extremities, and thus performs a kind of circular motion . . . It is absolutely necessary to conclude that the blood in the animal body is impelled in a circle, and is in a state of ceaseless motion; that this is the

act or function which the heart performs by means of its pulse, and that it is the sole and only end of the motion and contraction of the heart."

Bacon did not accept his doctor's discovery, and many lesser men were equally recalcitrant. But before Harvey's death the new teaching as to the circulation had supplanted that of Galen almost everywhere. The microscope, however, was not yet available for one necessary piece of demonstration. If the blood passes through the arteries from the heart, and returns through the veins to the heart, how does it reach the veins from the arteries ?

WILLIAM HARVEY DEMONSTRATING THE CIRCULATION OF THE BLOOD TO JAMES I.

Four years after Harvey's death the great Italian Malpighi, aided by the microscope, discovered the capillary blood-vessels, which had always been hidden from Harvey's eyes. The discoverer of the circulation never saw the essential fact of the circulation, which may nowadays be witnessed by the casual thousands in a music-hall, between a red-nosed comedian and a troupe of performing dogs.

Harvey was a short, dark, talkative, hot-tempered man, who wore a dagger in his younger days, and never tired of work. He had many enemies, but though his temper was so short in conversation, and he was apt to draw his dagger on the slightest occasion, in scientific controversy he was dignified and restrained. Thus he writes, " To return evil-speaking with evil-speaking, however, I hold to be unworthy in a philosopher and searcher after truth ; I believe I shall do better and more advisedly if I meet so many indications of ill-breeding with the light of faithful and conclusive observation."

Worthy also is his comment on the theft, by the command of Parliament, not merely of his furniture, but of much rarer things, while he was in attendance on the King: " My enemies abstracted from my museum the fruits of many years of toil. Whence it has come to pass that many observations, particularly on the generation of insects, have perished, with detriment, I venture to say, to the republic of letters."

Sir Thomas Browne thought Harvey's discovery greater than that made by Columbus ; John Hunter ranked Copernicus, Columbus, and Harvey by the side of each other. And we must not forget that Harvey,

in his later years, did splendid and epoch-making work in another direction.

In 1651 there appeared his "Studies of the Generation of Animals," to which he had devoted many years, and the value of which had survived the pitiable destruction of so much of his work, to which he alludes. He had made a practical study of the egg of the chick, and the stages of its development, but he was a comparative physiologist in the full sense—his work on the heart proves that—and before his observations were concluded he saw that all the higher animals begin from an egg—not the chick merely, but also the animals that are born alive, including man himself. This he definitely asserts in so many words; and such an assertion at such a date would alone suffice to stamp the genius of this great man. He had no microscope; words cannot say how he would have rejoiced in one; but he anticipated, in 1656, the discovery which had to wait until 1827, when the ovum of mammals was first seen. Harvey's great generalisation is commonly quoted as "Omne vivum ex ovo," which is thus the first rough statement of the truth, now known, that all the higher animals and plants are derived from a single cell. But Harvey had no microscope, and by direct observation knew nothing of the cell.

Before his death Harvey obtained some measure of the fame which his genius deserved. In 1654 he was offered the presidency of the Royal College of Physicians, which, however, he declined on the grounds of age. On June 3, 1657, he died, and was buried at Hempstead, near Saffron Walden. He left his library and a small estate to the Royal College of Physicians, of which he is the most illustrious ornament.

HIPPOCRATES

The Father of Medicine

Hippocrates was born in Cos about 460 B.C., though the details of his external life are dubious. He asserted himself to be the eighteenth in descent from the semi-legendary physician and deity, Æsculapius himself. Certainly he was one of the Æsculapiadæ, and his father was a physician. Like most great pioneers of ancient times, he seems to have travelled much in search of learning, though he spent a great part of his life in medical practice in Athens.

For long ages Hippocrates has been known as the "Father of Medicine," and the more we learn about him the more surely we see his right to that great title. His family was one of priest-physicians. He inherited great traditions, and bettered them. Whether on the side of philosophy, of clinical science, or of morals, Hippocrates is indeed the father of all true practitioners of medicine. He had the underlying ideas, the personal integrity, the practical methods, which mark his true disciples everywhere.

At the basis of his system we find the belief in what he called Phusis, or Nature, and in what the Romans were afterwards to call the "vis medicatrix naturæ." The business of the physician was to support this healing power of Nature when it was enfeebled. And Nature for him was divine. Such noble sayings as these are worthy of the author of the Hippocratic Oath—"Things are not in varying degree divine or human, but God is in all things;" "Everything is divine and everything human;" "The nature and cause of this illness rises from precisely the same divine from which all else proceeds." If we are rightly to appraise the aphorisms of the Father of Medicine, we must remember the long reign of the demonological theory of disease, before, during, and long after his time, with the burning and torture of countless invalids on the ground that illness was caused by devils.

Illness was due to natural causes, according to Hippocrates; not, therefore, to causes which excluded Deity from Nature, for Deity is everywhere. He is the very father, therefore, of those who study the living world for the causes of health and disease, yet find themselves thereby no further from the Divine.

The Greeks held the dead body in such reverence that it could not be dissected. Hippocrates therefore knew practically no anatomy, and he had to try to frame a rational system of medicine without knowing the difference between arteries and veins or nerves and tendons. So his theories inclined to be chemical, for lack of any anatomy on which to base them; and in this respect they read strangely like rude approximations to the latest pathological theories of our own times. The pathology of Hippocrates rested upon a humoral theory. The blood, the phlegm, black bile and yellow bile, were the four humours, four being chosen probably in order to correspond to the number of the "elements," as laid down by the Greek philosophers of the day. When we call a man sanguine, phlegmatic, melancholy, or bilious in temperament we are speaking the language of Hippocrates. Bodily health, also, was supposed to depend on these humours, according to their right production

and proportions. Man enjoys health, said Hippocrates, when each humour is in due proportion of quantity and force, but especially if they are properly combined.

This was a very wonderful theory for the age. It furnished a basis for observations; and no matter how inadequate or actually wrong it might be, it had the supreme merit of being a *natural* theory, as distinguished from all the superstitious theories. It referred the physician to the facts of physiology, and made medicine a science. Meanwhile, in the temples of Hippocrates' ancestor, the god Æsculapius was supposed to be performing such miracles as the restoration of eyes to empty sockets, and heads to headless shoulders. It falls also to be recorded that, as in all times and places, the followers of Hippocrates were unworthy of their great master, using images of the great physician as workers of magic, making animal sacrifices to them, and in general repeating all the folly and dishonesty which infested the worship of Æsculapius when Hippocrates was born to put medicine upon an honest basis.

Hippocrates could not anatomise, but he was a genuine clinical observer. Believing as he did in Nature, he tried to study the laws of health, and wrote upon them. His treatise on "Airs, Waters, and Places" is the first attempt to assert the principles of what we now call public health. In order to relieve dyspepsia, he saw that he must understand digestion, and thus he initiated clinical experiments with various kinds of food, given to healthy people, just after the fashion of Professor Pawlow and his followers today. He taught and treated patients in the famous Asclepion, or Temple of Æsculapius, in the island of Cos; but though the famous serpents were kept there for their healing powers, Hippocrates himself, notwithstanding that he was a hereditary priest-physician, would have nothing to do with priestcraft, with magic, charms, amulets, or incantations. Disease and health for him were natural phenomena, to be treated by natural means, and thus he prescribed baths, change of air, and suitable exercise, and paid very special attention to diet. Though destitute of anatomy, he did his best to study the "physical signs" of disease, as they are now called. He discovered how, by sudden movements, one could hear the splashing of water in a patient's chest if air were present also. This "Hippocratic succussion" retains its value today, at any rate in the absence of an X-ray installation, and the record of it by Hippocrates gave Laennec, almost in our own age, the idea of inventing the stethoscope for listening to the sounds produced by the body in health and disease.

Though dissection was forbidden, Hippocrates could at least study what we now call surface anatomy. He seems to have called in the artists of his day to help to record the facts which the eye could observe;

HIPPOCRATES FOUNDER OF MEDICINE, AND HYGEIA, GODDESS OF HEALTH

and we know that he presented to a temple a brass figure of a man in a state of extreme emaciation, thus showing as many anatomical details as could be revealed short of dissection. To this day we speak of the "facies Hippocratica," or facial appearance described by Hippocrates as characteristic of impending death.

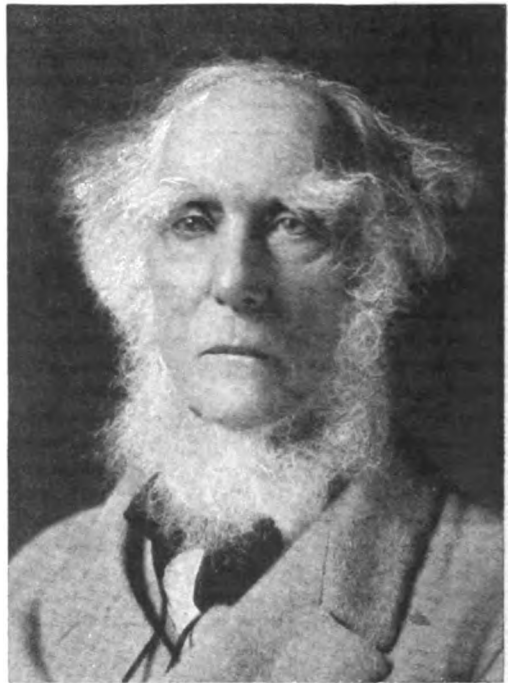
Though Hippocrates would have no more to do with priestcraft in the practice of

medicine, yet from his ancestry and traditions he derived the belief that the practice of medicine should only be discharged by men consecrated and sworn, as to a holy priesthood. Hence the Hippocratic Oath, still taken by him who would become a Doctor of Medicine, and pledging him to do his best for all his patients, never to abuse his knowledge, to lend no poison to unsworn hands, to reveal no professional secrets. Nor was this all. According to Hippocrates, the doctor "should have good manners, dress neatly, and avoid perfumes; he must be temperate, honourable, humane, modest, just, affable, and clean; he must oppose fraud and superstition, he must show courage in adversity, and he must have a due sense of Divine power, and recognise that to Heaven he owes success. In addition, he must have a good bedside manner, and must be calm and equable, even when those around him are agitated and excited."

Thus nobly was the profession of medicine founded by the great Greek physician who lived in Athens, when and where so many other great beginnings of civilisation, of art and scence, were being made. Democritus was one of those beginners, and his enemies asked Hippocrates to certify him insane, but the profound and honest student of living Nature declared Democritus to be the sane man, and his enemies mad. How long this great physician lived we do not know. According to some accounts, he survived to be a centenarian, but we do know that he died at Larissa, in Thessaly, having long retired from practice.

SIR JOSEPH HOOKER
A Great Evolutionary Botanist

Sir Joseph Dalton Hooker was born at Halesworth, in Suffolk, on June 30, 1817, and took a Glasgow medical degree in 1839. He was naturally destined, however, to be a botanist, his father being Sir William Hooker, of Kew Gardens. No sooner had he qualified at Glasgow than he went with the "Erebus" to the Antarctic region, with the result that, on his return, he published various volumes, now classical, upon the flora of those parts. Later he performed a similar service to botany for the Himalayas and British India. After many more travels, in Africa and America, he settled down at Kew, becoming Director of the gardens there, in succession to his father, in 1865. Thereafter he published many more works, such as his "Students' Flora," and his index to the flora at Kew. The noble gardens owe much of their present beauty and interest to Hooker.

He was known as a man of great age to students of the present generation. They honoured him not only for his researches in botany, but for his connection with the great story of the "Origin of Species." Many letters to and from him add interest to the correspondence of Charles Darwin, who greatly valued his opinion. He was consulted by Darwin at the critical date when Mr. A. R. Wallace's communication reached him from the other side of the equator, and he was present when the

SIR JOSEPH HOOKER
Photograph by Elliott & Fry

joint paper of Darwin and Wallace was read at the Linnean Society. On this he wrote: "The interest excited was intense, but the subject was too novel and too ominous for the old school to enter the lists before armouring."

Exactly fifty years later, Sir Joseph Hooker was present, and spoke, at the Linnean Society's celebration of the great episode. The doughty old nonagenarian was the admiration of all beholders, with his bright eyes, strong voice, and gallant bearing. He had to his juniors a perfect courtesy, an unlimited enthusiasm and interest in new things, which Time could not touch at all. He died on December 10, 1911.

SIR VICTOR HORSLEY
The Master-Surgeon of the Brain

Sir Victor Horsley was born in London on April 14, 1857, his father being the well-known painter J. C. Horsley, R.A. He studied medicine at University College, and soon began his important researches at the Brown Institution, of which he was Professor-Superintendent for six years. His work there specially dealt with the functions, then wholly unknown, of the thyroid gland. By experimental excision of the gland in animals he was able to show that certain definite symptoms result which closely resemble those of the disease known as myxœdema in man. The upshot of this most beneficent piece of research has been the introduction of the therapeutic use of the thyroid gland, obtained usually from the sheep, for the relief and cure of human beings suffering from myxœdema, from cretinism, or from any of the other manifestations of what is now termed "athyrea," or deficiency of the thyroid secretion.

Sir Victor Horsley next turned his attention to the study of the brain. Here, also, he made important experiments upon living animals, following and in close relation with those made by Sir David Ferrier. Thanks to him, our knowledge of the functions of certain convolutions and areas of the human cortex cerebri has been greatly extended. Naturally enough, the logical sequel to the surgical skill obtained and neurological data discovered by Sir Victor was his later work in the surgery of the brain. His work has been done especially at University College and the National Hospital for Paralysis and Epilepsy, where he has also taught for many years. Long before the year 1902, when he was knighted, Sir Victor Horsley had become the leading cranial surgeon, admittedly the successful pioneer of the most delicate and subtle branch of the whole surgical art. In that year he published his important paper on neuralgia, showing the results of his work in procuring surgical relief of intractable facial neuralgia by means of a daring operation upon the brain, and removal of the "Gasserian ganglion" from which the affected nerve springs.

In recent years Sir Victor Horsley, who is a prodigious worker, has found more and more time for the wider aspects of medical work. He contested Parliament for London University. He has interested himself greatly in the care of the London school children, and was conspicuous among medical men as a friend of the Insurance Act. Above all, he has been a great enemy of alcohol. His only book is "Alcohol and the Human Body" (with Dr. Mary Sturge), and he took a leading part in the demolition of the recent statistical paper which purported to acquit alcohol as a cause of degeneracy. Sir Victor is a born fighter, "not given to swearing in the words of any master."

ALEXANDER VON HUMBOLDT
A Student of the Distribution of Life

Alexander von Humboldt was born at Berlin on September 14, 1769. He early showed his bent for natural science, in which his appetite was omnivorous, and began to write on the geological and other phenomena of whatever place he found himself in. Soon his requirements led him far afield, and he became a very famous traveller. Beginning with five years in South America, he travelled later in Central Asia, and in between such expeditions found time for a great deal of work in political and diplomatic spheres, as well as for lectures upon his travels.

In 1845 he began the publication of his masterpiece, "Cosmos," which appeared in four volumes, the last published in 1858, the year before the author's death. In Humboldt's great work we find the qualities which were characteristic of Goethe, of himself, and of few men besides. Humboldt had early made geological observations. He had studied climate, had suggested the use of "isothermal lines," had named and studied "magnetic storms." He was thus an original master in the physical sciences, quite apart from his work as a naturalist. It is the astonishing range and breadth of his vision and his knowledge that astonish us.

All these qualities are combined in the magnificent work which he began to give to the world when he was already seventy-six. Nothing else of such rank and magnitude can be ascribed to so old a man in the whole record of human thought. It was worthy of the author's immense reputation, which was the very foremost in Europe, and its services to the popular reputation of science were incalculable.

Of course, the work was too ambitious. Science was younger in those days, and had no idea how little it knew. But Humboldt made a magnificent attempt to show the unity and grandeur of the cosmos in the light of all the multitudinous details, so many of which he had been the first to observe. At the same time, we do not

find in Hamboldt any of those great, seminal, epoch-making ideas or generalisations which count for almost everything in the history of knowledge, nor any of those immensely significant discoveries which count for all the rest. We shall probably be safe if we accept Darwin's opinion of him, expressed in a letter to Sir Joseph Hooker: "He was more remarkable for his astounding knowledge than for originality. I have always looked at him as, in fact, the founder of the geographical distribution of organisms."

Humboldt was undoubtedly a great man in character as well as in mind. He hated

ALEXANDER VON HUMBOLDT

slavery; he honoured and helped his juniors, generously praising them for their work, and always acknowledging what he took and learnt from them. His early experience of the conditions of mining led him to seek an amelioration of the miners' lot. As for his immense egotism, it may partly be excused as the natural result of the almost incredible fame which was his, and it undoubtedly helped him to achieve the great volume of work which stands to his record. He was perhaps the last of the encyclopædic philosophers, belonging to the same genus as Aristotle himself. Never can another Humboldt become master of so many sciences.

Just short of completing his ninetieth year, this remarkable man died, on May 6, 1859, a few months before the publication of the "Origin of Species." His elder brother, Wilhelm, was a great man in his day, being a notable student of philology. The two brothers were devoted friends, and the last twenty-three years of Alexander's life were desolate through Wilhelm's death.

JOHN HUNTER

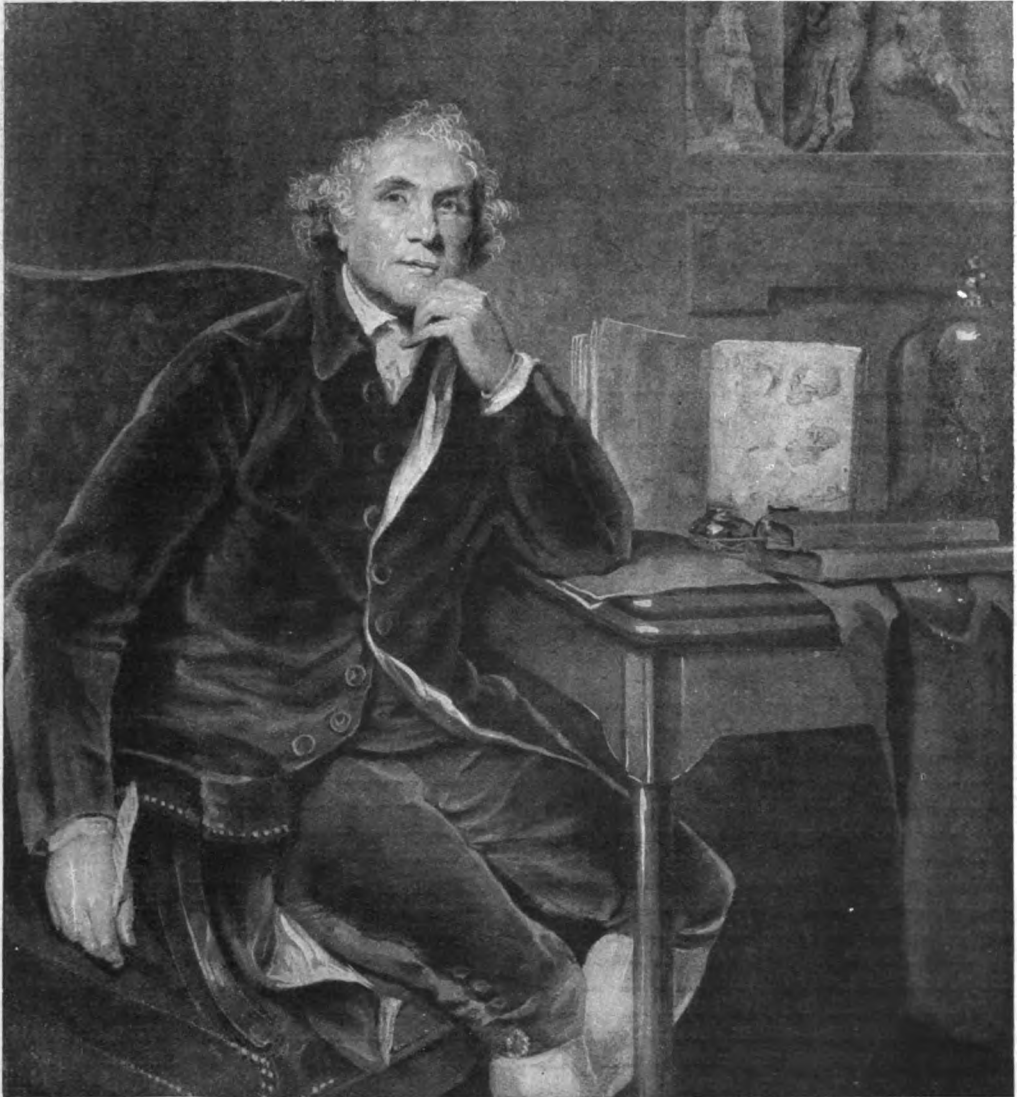
The Man who Made Surgery a Science

John Hunter was born at Long Calderwood, in Lanarkshire, on February 13, 1728. He was unsuccessful as a schoolboy, but found his true place when he was permitted to assist in the anatomical school, in London, of his elder brother, William, who was the leading practical anatomist of the time. Soon John Hunter desired to pass from anatomy to surgery, and in 1756 he became house-surgeon at St. George's Hospital. He had already done some splendid anatomical research work, partly independent and partly with his brother. To them we owe our knowledge of the lymphatic system of vessels in the body.

Next young Hunter gained some experience in military surgery, sailing with an English expedition to Portugal. His resulting treatise on gunshot wounds, published in 1764, is a classic upon that subject. Already he was collecting specimens of health and disease in man and animals, and thus laying the foundations of the incomparable museum which is now known by his name. When he came home, he settled down to practice and teaching. On one occasion, having ruptured his own *tendo Achillis*—the great tendon at the back of the ankle—he made a special study of the subject, with several experiments on dogs, and thus led to great improvement in the surgery of that tendon.

But it is quite impossible, in any reasonable space, to indicate the variety and extent and value of Hunter's original contributions to medicine and surgery, and to physiology. In Portugal he had studied hibernation in lizards, and the arrest of digestion during that period. Now he studied digestion in man, the treatment of the apparently drowned, the anatomy of whales, the hearing of fishes, the relation of wolf, dog, and jackal, and a host of subjects besides. No one who now deals with any branch of physiological science can avoid referring to some early research of Hunter's. Thus, to take the most recent example, which is the exact study of the nature of sex, we find Hunter first describing

the strange "mule" pheasant, which is an elderly female that has assumed the plumage of the cock. "To think is a delight," he said of himself, and he compared his mind to a beehive, inasmuch as its activity never ceased.

For some time Hunter took pupils, the most famous of whom was Edward Jenner, while Abernethy and Astley Cooper were others. It is difficult to understand when he found time to teach. Though he was in continual practice, he devoted a large amount of energy to general biological observations at his house in Earl's Court. There he kept innumerable animals from every part of the world. For fifteen years he had a flock of geese, for one particular purpose; and he kept everything else, from hedgehogs and hornets to leopards and eagles. By experiments on pigs he learnt the facts of the growth of bones, and by numerous experiments on other animals he learnt those possibilities of grafting which are now daily applied by surgeons to human beings. In this respect Hunter was a century before his time. His observations were directed to physiological purposes, but the possibilities of grafting which he demonstrated have since been invaluable for surgery. He was also a great

JOHN HUNTER, ONE OF THE GREAT FOUNDERS OF SURGERY

practical surgeon, inventing the celebrated operation for aneurism, which goes by his name, and meeting with much success, but his scientific researches altogether overshadow his surgical fame.

Though he hated lecturing, and lectured so badly that few of his pupils could follow him, he was compelled to spend some time on this uncongenial task. No doubt his practice was advantaged through these lectures, and thus, very fortunately for science, Hunter began to acquire large sums of money. He was the sort of man who should have much money to spend, for he knew what to do with it. He built for himself a museum, and in it placed his own collection, which had already cost him five figures, together with those of other collectors of the time. After his death, and with much difficulty, at last his collection was bought by the State, and handed over to the care of the Royal College of Surgeons. This is now the Hunterian Museum, in Lincoln's Inn Fields. When Hunter died it comprised nearly fourteen thousand specimens. These have since been vastly increased, and the collection is today without a rival.

Hunter's personal characteristics and habits are of exceptional interest. He combined the humility of the great man with a consciousness of his relative greatness. Of his mediocre contemporaries he said, " I know I am but a pigmy in knowledge, yet I feel as a giant when compared with these men." An incessant dissector, vivisectionist, and surgeon, he was yet a kind man, devoted to animals, and no butcher. He detested operations, never performed an unnecessary one, and was always trying to save the tissues and limbs of his patients.

At one time he was studying the growth of the deer's antlers, and thence he learnt how an artery may be tied, and yet other smaller arteries may compensate for its occlusion. Hence his most famous surgical innovation, which has saved untold numbers of limbs. Instead of amputating through the thigh for cases of aneurism of the great artery of the leg, when bursting and fatal hæmorrhage threatened, Hunter ventured to tie the artery above the aneurism, in the belief that other arteries would come to the rescue and nourish the limb adequately, as in the case of the deer's antlers, the principal artery of which he had tied. His hope was justified, and through it he established a new and beneficent principle in surgery.

At bottom this man was a biologist in the full sense. The nature of life, which is the essential problem of biology, was incessantly in his mind. He knew enough to know that he could not solve this problem. " We are but beginning to learn our profession," he would say ; but he unswervingly devoted himself to the gathering of facts and specimens which should some day enable his successors to answer the question. He experimented on trees ; he collected crystals in order to compare their growth and formation with the analogous phenomena of living things ; and he always denied that life is the result of mechanism, though the mechanisms of life in all its forms have never had a more devoted and illustrious student. Life for him was a great chemist, a directive principle, which used, while it obeyed, the laws of physics and chemistry. As one of the greatest of comparative anatomists—indeed, he has no rival in this field—he was naturally struck by the resemblance between living forms ; and there are passages in his works which suggest that he was inclined towards the belief in organic evolution, though others definitely refer to special creation as an accepted assumption.

He seems to have required very little sleep. At five or six in the morning he was to be found dissecting, and his friends and pupils left him at midnight " with a lamp fresh trimmed for further study." For many years he suffered from symptoms of arterial degeneration, but he had the great wisdom to forswear alcohol altogether during the last twenty years of his life, like Dr. Johnson in similar circumstances. Thanks to his temperate and regular habits he was able to go on working, but his temper was always hot and short, and opposition was apt to bring on attacks of angina pectoris. A contradiction at a board meeting at St. George's Hospital, on October 16, 1793, proved fatal. His mortal remains now lie in Westminster Abbey, and his fame has increased in every decade since his death. He made surgery a science ; and, as has been said, " When we make a discovery in pathology, we only learn what we have overlooked in his writings or forgotten in his lectures."

THOMAS HENRY HUXLEY

Researcher, Fighter, and Truth-Seeker

Thomas Henry Huxley was born at Ealing on May 4, 1825. He studied medicine at Charing Cross Hospital, and began to practise in the East End, after taking his degree at the age of twenty. Like

Darwin and Hooker, who were afterwards to be closely associated with him, he went on a voyage which introduced him to many of the great problems of biology. For four years he was away as assistant-surgeon to the "Rattlesnake," meanwhile making researches and sending them home. When he himself returned, he began to teach natural history in the Royal School of Mines. He never held a university Chair.

The life-work of Huxley may be readily divided into more or less independent parts. He was a great original student, though the fact is often forgotten. He discovered "Huxley's layer" in the roots of the hairs when he was still at Charing Cross Hospital. His studies of the medusæ won him his F.R.S. when he was only twenty-six. He founded our modern classification of birds. He was a master of palæontology, and his "Physiography" and "The Crayfish" are masterpieces in the art of exposition for the serious student. For clearness and force of writing, for precision of thought, and for scrupulous honesty of statement, Huxley has never had a superior among scientific writers of any age or land.

A great researcher, a great teacher, Huxley was, nevertheless, above all, a great biological thinker. It is in that capacity that his life-work matters so much for our own times. His mind was free; and when the "Origin of Species" appeared, and sorely needed champions, Huxley was ready. Darwin humorously calls him somewhere "my good and admirable agent for the propagation of damnable heresies." Not that Huxley was by any means prepared to take Darwinism on trust. For many years he declined to accept the essential teachings of the "Origin," and he always regretted—with just prescience, as we now know—Darwin's insistence on the dictum that Nature does nothing by leaps, and that species change only by insensible gradations.

But Huxley soon became the leading champion of the idea of organic evolution—apart from that specific theory of its causation which is called Darwinism—against all the arrayed forces of conservatism, inertia, and *odium theologicum*. At first he was a very indifferent lecturer, but his writing was tremendous. There never was a more deadly controversialist, as one famous adversary after another found to his cost, from Bishop Wilberforce at the British Association, to the late Duke of Argyll, Mr. Gladstone, and Dean Wace. His courage was unlimited. Only four years after the "Origin," there appeared Huxley's book on "Man's Place in Nature"—now republished in Mr. Dent's Everyman's Library—in which the relation of man to the anthropoid apes was frankly asserted. No one of the present generation can easily imagine the sensation, the fury, the boundless and rabid indignation which these views of Huxley excited.

Because this man was a profound thinker, as well as a great fighter, he never confounded the fact of Evolution with any theory of its causation. He never overstated the case for the Darwinian theory, or concealed its weakness. But he roundly declared that "the doctrine of Evolution is a generalisation of certain facts which may be obtained by anyone who will take the necessary trouble;" and that to this doctrine "all future philosophical and theological speculations will have to accommodate themselves."

Exactly half a century after the publication of "Man's Place in Nature" everyone knows, outside the Roman Catholic Church, that Huxley was right. The fact of evolution is proved; and the problem for us and for the future is to discover and define its causation. Here, of course, it has been repeatedly said that Huxley was a dogmatic and unqualified materialist. In some respects he was so, as in his celebrated "epi-phenomenon" theory of the mind; but they know very little of him who say that his view of the Universe as a whole was materialistic. On all ultimate questions he said, "I do not know," and thus he coined, for himself, the term "agnostic," by way of contrast, he said, to the Gnostics, who asserted that they knew so much. Agnosticism, as Huxley held it, neither asserts nor denies. He condemned negative assertions about matters beyond our scope, just as he condemned the positive assertions of the dogmatists. There may well be, he said, modes of being, part of the Universal Whole, "in the midst of which, indeed, we might be set down, with no more notion of what was about us than the worm in a flower-pot on a London balcony has of the life of the great city."

Beyond doubt, Huxley was a great lover of Truth. It was the passion of his life. He valued it for itself, and for the salvation of mankind. In his writings on social and political matters we find actively expressed his belief that not the popular vote but the amount of Truth known to a nation can save it. "The first-recorded judicial murder of a scientific thinker [Socrates]

was compassed and effected not by a despot, nor by priests, but was brought about by eloquent demagogues."

Of all Englishmen during the second half of the nineteenth century, Huxley was probably the most potent maker of public opinion. His scientific rank was beyond question, as his presidency of the British Association and, above all, of the Royal Society showed. No one could question his sincerity, his real belief in the saving efficacy of scientific truth. He was a very hard hitter; but we need to exhume the forgotten writings of his opponents in order to discover the kind of thing against which he had to defend himself—and he was fighting not for his own hand or his own ideas. His "Lay Sermons," first published in 1870, many of his collected essays, his "Physiography," and many more of his general writings, as upon Hume and Berkeley, are as valuable as ever they were, and find more readers than ever today.

He died at Eastbourne on June 29, 1895, and his Life has been wrtten by his distinguished son, Mr. Leonard Huxley.

EDWARD JENNER
Conqueror of a Foul Disease

Edward Jenner was born at Berkeley, in Gloucestershire, on May 17, 1749. In 1770 he became a pupil of the illustrious John Hunter, in London, and established with him a friendship that never failed. Three years later Jenner returned to his native place, and began to practise with much success. In a year or two he became interested in the popular tradition that there was a relation between cowpox and smallpox, so that a dairymaid, for instance, who had contracted the one would be protected against the other. Smallpox was at that time an extremely common and deadly complaint, carrying off very large numbers of infants and young children in especial.

Jenner worked at this subject for more than twenty years with great patience and skill. He began by distinguishing true cowpox, or vaccinia, from a very similar eruption which, nevertheless, is quite distinct, and offers no protection against smallpox. Jenner had already succeeded in interesting Hunter, at whose suggestion he had made many investigations, but no one really believed that this research of his was more than a curiosity. However, twenty-one years after he had begun, he was able to show experimentally that the inoculation of smallpox matter failed to produce the disease in a boy who had been successfully vaccinated six weeks before.

From this date onwards Jenner met with success, though he had many difficulties to encounter, especially in the form of professional jealousy. His discovery owed its wide practical application to a few enthusiastic laymen, while certain doctors tried to get the credit of it for themselves, and nearly succeeded in supplanting Jenner, who had now been working at it for a quarter of a century. Six years, however, sufficed to make vaccination as widely spread as civilisation itself; and we who today have no idea of smallpox need to turn back to contemporary chronicles in order to realise how Jenner's discovery was valued in its earliest years. The anniversary of his birthday was long celebrated as a feast in Germany; in the Roman Catholic countries religious processions were formed for the reception of the blessing of vaccination; and Parliament voted Jenner ten thousand pounds in 1802, and twenty thousand more a few years later.

The vast and unprecedented honour in which Jenner was held abroad was by no means equalled in his native land, nevertheless. Though Parliament appreciated vaccination, it still allowed inoculation for smallpox to continue, as introduced by Lady Mary Wortley Montagu, and thus the disease was widely spread when no excuse for the practice of the older measure remained. Jenner loved the country, and his work suffered greatly by the fact that he did not live in London, where there was a long succession of rivalries and alternate attempts to decry and to exploit vaccination in the interests of others. His native place was always home to him; and after a visit to London in 1814, when he was presented to many Royal personages, he never returned to the metropolis—of which the Royal Society had refused his first paper, and the Royal College of Physicians would not admit him a Fellow unless he passed an examination in classics.

On January 26, 1823, he died at Berkeley; and ninety years later we find the leading medical and bacteriological investigators of the world employed in the task of finding for other diseases the application of the very principle which Jenner applied to smallpox. For several years this work has been done with notable success at the Jenner Institute in London, the name of which, owing to the existence of a commercial firm of the same name, was changed, a few years ago, to the Lister Institute.

LEARNING TO LISTEN FOR DISEASE

RENÉ LAENNEC, THE FRENCH DOCTOR WHO INVENTED THE STETHOSCOPE TO HEAR CHEST-SOUNDS
From the painting by Chartran in the Sorbonne, Paris.

ARTHUR KEITH

A Forger of the Chain of Man's Past

Professor Arthur Keith was born in 1866, and educated first at the University of Aberdeen, and then in London and abroad. He early devoted himself to anatomical research, and especially to the problems of the relation between the body of man and that of the anthropoid apes. Having spent some time in Southern Asia, he made a special study of such important and interesting animals as the gibbon, and his first volume, published in 1896, dealt with the anthropoid apes in general. On this subject he is now the acknowledged master.

For some years he taught anatomy at the London Hospital, and then he took charge of the Hunterian Museum, and was appointed Hunterian Professor to the Royal College of Surgeons. As such, he delivers lectures every year to the small number of students who can be found to attend any really authoritative and original courses of lectures in the metropolis, other than those qualifying for diplomas. Professor Keith has already discussed the supremely interesting subject which, until the last few years, had made little advance since the publication of Huxley's volume on "Man's Place in Nature," fifty years ago. His views are based on such wide knowledge that their publication for the instruction of many readers and students would be highly desirable. He regards the gibbons as the nearest living animals to the ancestors of man. The larger anthropoids and ourselves have all departed, in one way or another, from the simpler and smaller form represented by the gibbons. These creatures probably yielded the stock whence man is derived several millions of years ago, according to Professor Keith.

They are of special interest, also, in that they show us the "upright posture," or "erect attitude," at a date long before the evolution of man. But it is upright with a difference: for whereas man is upright from his feet, the gibbon is upright, or perhaps we should say downright, from its hands. This creature moves about, in the vertical axis, suspended from its hands. Man's assumption of the erect attitude has a different history; and we are entitled to say that, hitherto, man has not succeeded in adapting himself to this attitude as well as the gibbon has in its way.

Early in the year 1913 Professor Keith delivered a new series of lectures, first, upon man's assumption of the erect posture; and second, upon the diseases and disabilities which are liable to attend that posture. Especially in the modern civilised man, who leads a highly unnatural and sedentary life, do we find that the abdominal contents tend to sag, and become kinked and congested by their own weight, when the tone and quality of the muscles do not suffice to compensate for the downward pull of gravitation. More especially it is woman who suffers from the erect posture, partly because of her lesser muscularity, and notably in association with childbirth. The "curse of Eve," which places the human mother at so serious a disadvantage,

EDWARD JENNER

compared with sub-human mothers, is essentially dependent upon the human assumption of the erect posture.

Within the last year or two, Professor Keith has written two semi-popular books, which have found many readers, and which must have greatly helped in bringing the knowledge of thoughtful laymen up to the level of contemporary inquiry. These two books, to be commended without reserve, are "Ancient Types of Man," in the "Library of Living Thought," and "The Human Body," in the "Home University Library." The former is the best work of its kind in our language, and contains a number of admirable drawings and diagrams, which

give a very clear idea of such remains of primitive man as have hitherto been found. The author's rank and trustworthiness may be estimated by the fact that he has just been elected President of the Anthropological Institute, which is now assuming a new importance, thanks to the number and significance of the ancient human remains that have been found in this country in the last year or two.

The little volume on "The Human Body" gives just those data of anatomy which concern every thinking man, though they may be of little interest to the mere dissector or the surgeon. It is well to know that, in Professor Keith's opinion, the human body at the present time shows no signs of degeneration in any essential respect. We are taller, stronger, longer-lived than our ancestors. In the alimentary system, however, and there alone, signs of degeneration may be found, but these he regards as dependent merely upon the unsuitability of our diet. What with an unnatural, excessive, unnaturally prepared and improperly masticated diet, introduced into an alimentary system which is at a disadvantage, owing to our assumption of the erect posture, it is no wonder that dyspepsia, appendicitis, and constipation are so common.

ELLEN KEY
A Champion of Feminism

Ellen Key was born at Sundsholm, in Sweden, on December 11, 1849. She is descended on her father's side from the Scottish MacKays, one of whom fought under Gustavus Adolphus. When quite a young girl she wrote some novels on Scandinavian peasant life, under the influence of such writers as Björnson. Later she travelled widely in the company of her father, who was a distinguished member of the Swedish Parliament; and when he lost his property as the result of an agricultural crisis she began to teach in a girls' school.

Afterwards she occupied a professorial Chair in Stockholm, but not until the present century did she begin to produce her important books. An old Swedish law against heresy was revived in order to send to prison some young men who had argued upon Darwinism. Ellen Key, who is a great orator, came forward to protest publicly, and then, in consequence of extensive abuse to which she was subjected in Sweden, she felt impelled to write.

She was first appreciated in Germany, which is, perhaps, among the leading countries of the world, the best fitted to accept the particular form of feminism, based upon the biology and psychology of woman, which Ellen Key advocates.

Many years ago, Ellen Key found herself compelled to protest against the aims of those feminists who preach sex antagonism, and who especially desire the evolution of woman to proceed on masculine lines. In 1909 appeared her book "The Woman's Movement," which was published in this country and the United States in an English translation in 1913.

The English reader can already possess himself of "The Century of the Child" and "Love and Marriage." By general consent, "The Century of the Child" is a work of the highest authority, especially in its chapters on education. Therein speaks a woman who has had long experience of teaching, who is a child-psychologist, and who adds a woman's intuition to the scientific knowledge which we owe to such men as Professor Axel Key, the distinguished educationist, who is her brother.

"Love and Marriage" is a much more important volume, because of the problems with which it deals, and the daring with which they are attacked. In this book the author shows herself a champion of the sanctity of love, and of the personality of each man and woman. Her conception of marriage as a union of the senses and the soul is nobly stated and defended, and we find that she comprehends and extends Galtonian eugenics in something for which, unfortunately, she can find no better name at present than "erotoplastics"—the making of the future through love. At the present time this book is the centre of active discussion in Europe and America, but the reader must be warned against accepting all the critical statements of its teaching, which is inexcusably parodied and misstated in, for instance, the volume "Marriage and the Sex Problem," translated from a Swiss writer, and published in this country at the end of 1912.

ROBERT KOCH
Discoverer of the Cause of Consumption

Robert Koch was born in Hanover on December 11, 1843. He received his medical education at Göttingen, and soon began to work at bacteriology, along the lines which were just being laid down by Pasteur. So successful was Koch in this field that he will always take rank as the first and greatest follower of the immortal Frenchman.

As early as 1876, Koch obtained a pure culture of the anthrax bacillus, and thence he was able to devise preventive methods of inoculation which have proved very valuable. In 1882 he made his chief discovery, of the bacillus of tuberculosis, which had long been sought, but yielded up its secret only to the ingenious technique which Koch had spent years in elaborating. In the following year Koch was appointed Director of the German Cholera Commission, and succeeded in identifying the comma bacillus, as it is called from its shape, which is the cause of that terrible disease.

In 1885 Koch was made Professor in the University of Berlin, and Director of the Institute of Hygiene. He set himself the task of elaborating, from tubercle bacilli, a remedy for consumption. In 1890 he introduced his tuberculin, which was hoped to prove a cure for consumption, but it proved inadequate, and caused intense disappointment. It had its uses, however, especially in diagnosis. Later, Professor Koch introduced a new tuberculin, called "Tuberculin R," which is much more valuable. At the present day the use of the new tuberculin is spreading very rapidly, and its utility is beyond question. Röntgen ray photography of the lungs has recently been perfected, so that the action of any remedy upon those organs can be definitely traced from week to week, and the value of tuberculin can no longer be denied. The best and most beneficent results of Professor Koch's life-work are thus being realised only after his death.

In 1901 Professor Koch made a remarkable announcement at the London meeting of the International Congress on Tuberculosis, to the effect that the tubercle bacillus of man and the ox are wholly distinct, the latter being innocuous to man. Undoubtedly Koch was wrong in this statement, which was based on inadequate experiment, and has since been disproved, especially by the work of the Royal Commission on Tuberculosis, appointed in this country after Koch's pronouncement.

In the 'nineties Koch studied the rinderpest of South Africa, and also the bubonic plague in India In the latter years of his life he made further expeditions in Africa, and found the organism of sleeping sickness to be present, as an apparently innocuous parasite, in the blood of many large animals, such as the crocodile. This discovery led to the demand for *carte blanche* for big-game hunters in Africa; but it is probably not necessary to exterminate all the larger African fauna in order to control sleeping sickness. Professor Koch died in Berlin on May 28, 1910.

ELLEN KEY, THE INTELLECTUAL INSPIRER OF TRUE WOMANHOOD, AT HER HOME IN SWEDEN

RENÉ LAENNEC

Inventor of the Stethoscope

René Laennec was born at Quimper, in Brittany, on February 17, 1781. His uncle made a doctor of him, and after studying at Nantes he took his degree in Paris in 1804.

He devoted himself especially to the study of pulmonary tuberculosis or consumption, and added much to our knowledge of the ravages produced in the lungs by that disease. In 1816 he became chief physician to the Necker hospital, and there he tried to devise better methods for studying the condition of the lungs during life. Everyone knows that the breathing may produce audible sounds, such as "wheezing." These sounds are louder when the ear is applied to the chest, and then one hears not only normal and abnormal sounds of respiration, but also the beating of the heart. This is the means of diagnosis which is now known as immediate auscultation. It is susceptible of little precision, for the ear, thus used, gathers sounds from far too large an area of the body. Laennec needed something better, and so he invented the wooden tube which he called the stethoscope, meaning literally something that sees inside the chest.

In 1819 Laennec published his celebrated "Treatise on Mediate Auscultation," in which he described the use of the stethoscope by the method of auscultation with the medium to which he gave that rather unsuitable name. In the Röntgen rays we now have a veritable stethoscope, and can actually see inside the chest, but the value of Laennec's simple invention remains. For many purposes it is best elaborated, with two ear-pieces and a couple of indiarubber tubes, forming the "binaural stethoscope." By means of Laennec's invention the physician can make a minute study of the sounds produced by small areas of the body, and the early diagnosis of consumption in especial has been greatly facilitated.

For a short period Laennec taught medicine in the Collège de France, but his health was undermined, and on August 13, 1826, in his maturity of knowledge and intellectual power, he died, a victim to the terrible disease which he had spent the greater part of his life in studying.

JEAN BAPTISTE LAMARCK
The Real Founder of Organic Evolution

Jean Baptiste Lamarck was born on August 1, 1744, at Bazentin, in Picardy, of a noble family. His father destined him for the Church, and he studied with the Jesuits at Amiens, but when his father died he joined the army. At Toulon and in Monaco he became interested in the superb and varied flora of the Mediterranean. When his ill-health compelled him to leave the army, he started the study of medicine in Paris. Botany still interested him particularly, and, thanks to Buffon, he obtained a post which gave him the chance of travelling through Europe and studying plants everywhere. He published many treatises on botany, and gained a great reputation.

Then, when most men have finished their original work, came Lamarck's opportunity. He had to turn his attention from botany to zoology, on which subject he began to lecture when he was just short of fifty years old. For a quarter of a century he studied and lectured on zoology, and especially upon those animal forms to which he himself gave the general name of invertebrates.

For us, today, Lamarck stands out as the supreme naturalist of his time, and as one without a superior in the whole history of biology. His countrymen have long appreciated him, though Cuvier's influence was supreme during his life; but in this country it is, or was until lately, still the fashion to look upon Lamarck as a fantastic speculator who had one or two good ideas, but no substance behind them. In our insular estimation, the great name of Darwin completely overshadows that of his French predecessor, but recent students are coming to see that Darwin's own estimate of Lamarck is really the more trustworthy.

The great work upon which the fame of Lamarck will always securely rest is his "Philosophie Zoologique," published in 1809, the year of Darwin's birth, and exactly half a century before the "Origin of Species." This "justly celebrated naturalist," as Darwin calls him, first published his views in 1801, and he finally amplified them in his great "Natural History of Invertebrates," which was published in 1815. But the "Philosophie Zoologique" is his acknowledged masterpiece. In Darwin's words, "In these works he upholds the doctrine that all species, including man, are descended from other species. He first did the eminent service of arousing attention to the probability of all change in the organic as well as in the inorganic world being the result of law and not of miraculous interposition. Lamarck seems to have been chiefly led to his conclusion on the gradual change of species by the difficulty of distinguishing species and varieties, by the almost perfect gradation of forms in certain groups, and by the analogy of domestic productions."

"With respect to the means of modification, he attributed something to the direct action of the physical conditions of life,

something to the crossing of already existing forms, and much to use and disuse—that is, to the effect of habit. To this latter agency he seems to attribute all the beautiful adaptations in Nature, such as the long neck of the giraffe for browsing on the branches of trees. But he likewise believed in a law of progressive development; and as all the forms of life tend thus to progress, in order to account for the existence at the present day of simple productions, he maintains that such forms are now spontaneously generated."

Lamarck did not live to see his views accepted, partly owing to the influence of Cuvier, but mainly owing to the simple fact that he was far in advance of his time. It was quite different fifty years later, when "evolution was in the air." If we remember how, even then, the "Origin of Species" was received, though it contained practically no reference to man, we may imagine how unready the world was in 1809 for the theory which denied the constancy of species, denied special creation, and included man in a general doctrine of "transformism" or "theory of descent," to use the older names. Yet Lamarck was a colossus; and at this very day the experimental study of evolution is directed, all over the world, to these very theories which he put forward a century ago—above all, to the influence of what he called the "milieu environnant," translated by us as the "environment."

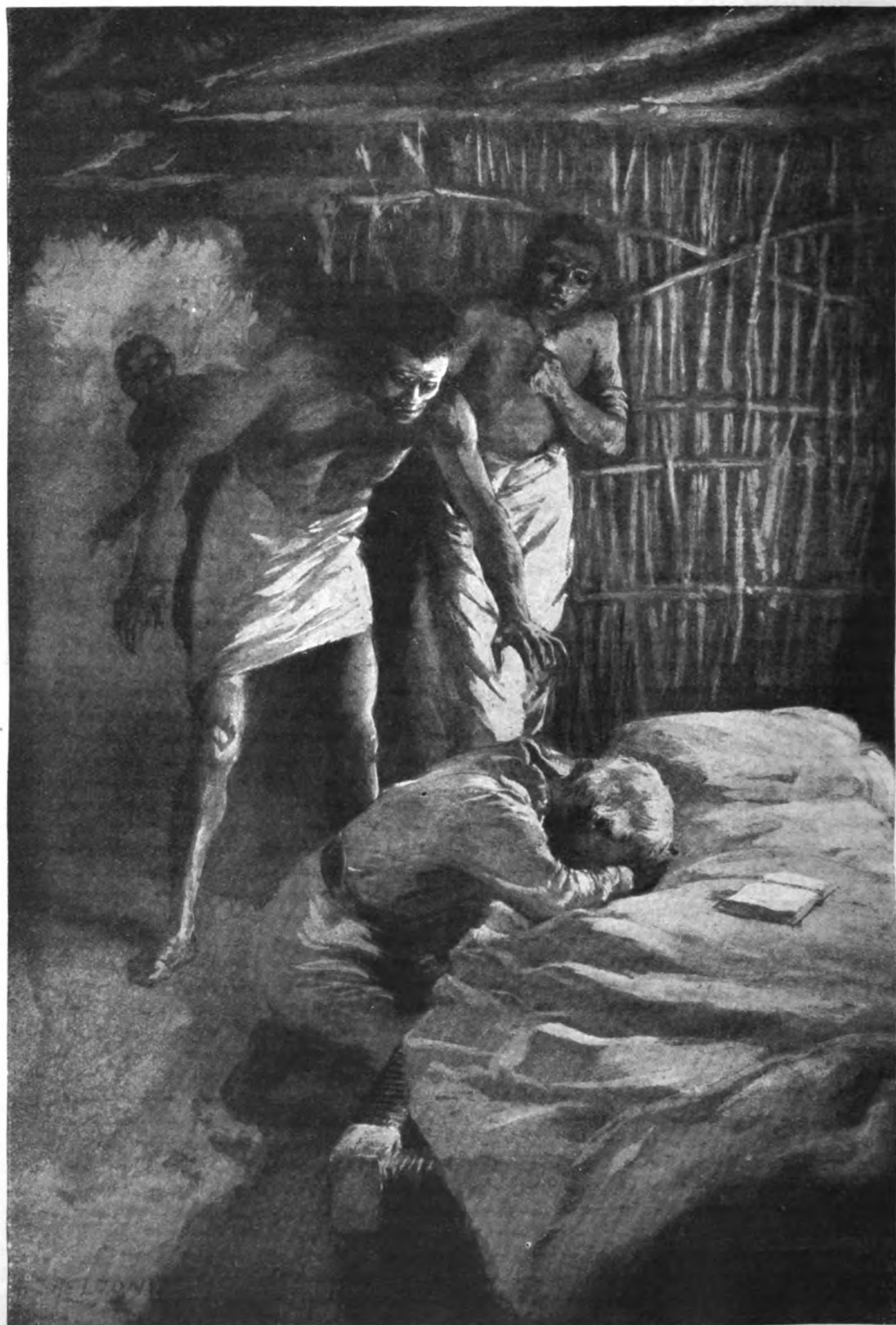
To Lamarck we owe the use of the term "biology." He came to the study of animals after many years devoted to plants, and thus he saw life as a whole, without the narrowness which specialism usually involves. Further, he had the great advantage of being required to begin with a special study of the invertebrates. The larger animals, the birds, mammals, and reptiles had been chiefly studied, and they are all so definite and distinct that they favoured the idea of "special creation." No one before Lamarck had made any proper study of the invertebrates, which were smaller and less like man, and therefore less interesting. But among these animals "not the marked differences, but the numerous relations, the endless varieties and resemblances, seem to command our consideration." Are we really to believe that the eighty thousand varieties of beetles were each separately created? In Lamarck's own words, these humbler forms of life seem to be much more likely to "make us understand the beginnings of all organisation, as well as the cause of its complexity and its development."

Approaching biological problems from the side of botany, and then studying especially the simpler animal forms, Lamarck always laid special stress upon environment, which is so obviously potent to change the form of plants, though we do not see such large consequences of its action upon the structure of the higher animals. He argued, further, that these environmentally induced changes could be inherited, so that species might thus be modified. This is the part of his theory which is most generally known; but the curious fact is that Lamarck has been almost wholly made known to the world not in his own writings, but by his critics, who were not fair to him. Thus we find Darwin attributing to Lamarck various statements, and condemning them as "nonsense," and "veritable rubbish"—which, in fact, cannot be found in his writings; and it is on record that Sir Charles Lyell, when he studied Lamarck for himself, found that he had done him injustice.

Now that we see the theory of "natural selection" to tell us nothing as to the origin of the forms which Nature has selected, or tolerated, we find that we require to frame some other theory as the origin of progressive variations. And then we find that Lamarck was in the field a century before us. All possible theories as to the new origin of new forms are already to be found in his writings. We now all admit what he asserted—that "species have arisen by natural causes," and not by "special creation," and it remains only for us to submit the Lamarckian theories to experimental observation. What are the effects of use and disuse, of modified nutrition, of bi-parental reproduction, and so forth?

Lastly, Lamarck always believed and taught that function precedes and creates structure. He allows something for the internal force, "élan," purpose, of life itself. In this respect he is definitely not a mechanicist, but is to be looked upon as the logical predecessor of such a naturalist as Driesch today, or such a philosopher as Bergson.

Lamarck was a devoted worker, and ultimately lost his vision in the service of knowledge. In his latter years he was blind, and very poor, but, thanks chiefly to his eldest daughter, he went on working, and completed his natural history of invertebrates in 1822. Thus, blind, in poverty, and disbelieved by his contemporaries, died the founder of organic evolution, on December 18, 1829.

THE FITTING CLOSE OF A GREAT CAREER

LIVINGSTONE'S FAITHFUL FOLLOWERS FINDING HIS DEAD BODY IN AN ATTITUDE OF PRAYER

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EXPLORERS

JAMES AUGUSTUS GRANT—EXPLORER OF THE SOURCE OF THE WHITE NILE

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HENRY HUDSON—AN ELIZABETHAN IN QUEST OF THE NORTH POLE

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SIR HENRY AUSTEN LAYARD—THE MAN WHO FOUND A LOST WORLD

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SIR GASTON CAMILLE MASPERO—WHO DUG UP AN ANCIENT CIVILISATION

JAMES AUGUSTUS GRANT

An Explorer of the Source of the White Nile

COLONEL JAMES AUGUSTUS GRANT, born at Nairn on April 11, 1827, entered the Bengal Army in 1846, and chummed up in India with another British officer, Lieutenant Speke. They were both the same age, and both fond of field sports, and by reason of its results their friendship afterwards became famous. Grant went through the Indian Mutiny, his own regiment having rebelled, and he was wounded at the Relief of Lucknow. In 1858 he came back to England to recover his health; and when Speke was commissioned by the Royal Geographical Society to discover the actual source of the Nile, his old friend volunteered to go with him.

They left Plymouth on April 30, 1860, and on October 2 set out from Bagamoyo, now a town in German East Africa. After a march of 500 miles, they arrived at Kazeh. Their mules died, their native followers fell ill, and Grant became delirious with some tropical fever. Three attacks of it so weakened him that he could not walk, and Speke was obliged to leave him behind and go on alone to Uganda. Though in great pain, Grant had himself carried northward, and joined Speke after a separation of four months. Nearing the source of the Nile, they again divided, Speke going by the water route, and Grant by the land tract. So it fell to Speke to discover the Ripon Falls, where the Victoria Nyanza discharged itself to form the main waters of the White Nile.

The two friends had much trouble with the king of the country north of Uganda. He would not allow them to pass through his territory, for he had heard that the two white men were cannibals who required a supply of men and women for their daily food, and drank enormously. But by tact and patience Grant managed to win the favour of the king, who then became troublesome in another way. He would not let the two explorers depart, but wanted them to assist him in his wars. However, they sailed up the White Nile, and, striking through a great forest, came upon a camp of Egyptian ivory-traders. By keeping with their caravan of three hundred men they reached Gondokoro on February 1, 1863, where they met Sir Samuel Baker.

"You have had a long walk, Captain Grant," said Lord Palmerston, when the Scottish explorer returned to London. For some years Grant was only regarded as the lay figure in the discovery of the source of the Nile. Loyalty and modesty led him to postpone his fame and interests to his friendship, and all the credit for the results of the expedition was generally ascribed to Speke. But, as a matter of fact, if Speke, with his experience, was the leader in the work of exploration, Grant was the soul of the expedition. Educated at Marischal College, Aberdeen, in botany, natural history, chemistry, and mathematics, he supplied the scientific knowledge in which Speke was deficient. While Speke lived, he gave him all the results of his researches and studies, with the sole idea of enhancing the renown of his friend. It was with some difficulty that Speke induced him to write a separate book on the domestic life and racial traits of the peoples with whom he had lived in the unknown parts of Central Africa. As Goldsmith said, "modesty is a plant that only grows in a noble soil."

During the Abyssinian War, Grant served in the intelligence department of the army of rescue. As his health was impaired by his former toils and fevers, he retired after the war from the Service, and spent the rest of his life mainly at Nairn, where he died, on February 11, 1892.

SIR SVEN ANDERS HEDIN

Explorer of the Desert of Central Asia

Sven Anders Hedin, the greatest of living Asiatic explorers, is the son of a Swedish architect, and was born in Stockholm in 1865. Educated in his native town and at

the chief university of his country, Upsala, he began his life's adventure at twenty by wandering through Mesopotamia and Persia. In 1890 he was a member of an embassy sent by King Oscar to the Shah of Persia, and he profited by this occasion for studying further the languages of Asia. Thus he made a journey through Khorasan and Turkestan, picking up more curious foreign tongues. He went as far as Kashgar to ascertain if it would serve as a base of operations for the exploring of the heart of Asia, on which he had long set his mind. His interest in Persia was so aroused that he returned to it later overland from the Black Sea, and made a most useful journey through the salt deserts to the eastward of Teheran, and so by way of the River Helmund and Beluchistan reached India. During the journey he traced in part the historic route of Marco Polo through Persia.

COLONEL JAMES GRANT

For several years Hedin had been busy studying the geography of Central Asia, partly at home, and partly at the University of Berlin, under Baron von Richthofen, who had won fame by his scientific exploration of China in 1860 and 1868–72. Richthofen's teaching was especially valuable, for he was a first-rate geologist, as well as a geographer, It is doubtful if any man, and particularly any young man with the ambition to explore unknown countries, has ever trained himself so thoroughly for his work as Sven Hedin did. With a magnificent physique and a well-stored mind, he set out in 1893, knowing already the most important languages he would need in his lonely journey, and with a practical experience of native ways and Asiatic travel. He had dreamt a dream in early boyhood when Nordenskjöld had thrilled all his Swedish countrymen by sailing from Sweden to the Pacific Ocean by the North-East Passage so vainly attempted for hundreds of years.

Hedin was attracted by the mystery and perils of the vast deserts of Central Asia, and he devoted all his youth and early manhood to the task of preparing himself for his great adventure. He learned to draw, to climb, to sail, to use all the scientific instruments in any way helpful to him; and in spite of his intense study he kept himself as fit as an athlete training for a long race. Setting out from Stockholm on October 16, 1893, he travelled by steamer and rail to Orenburg as his starting point. He returned to Stockholm, by way of Peking, on May 10, 1897.

Between these dates he had crossed in two directions the most terrible desert in the world, the Takla-makan; he had explored unknown regions in northern Tibet, and made three excursions in the Pamirs; he had cleared up the mystery of a strange desert lake, Lop-nor, mentioned by Marco Polo, and had generally drawn back the curtains of darkness that covered a large part of Central Asia. He had mapped out thousands of miles, investigated the geology of unknown regions, studied the winds, moisture, and temperature on plains and mountains and wildernesses, had mixed on friendly terms with unknown tribes, learnt their customs, measured their heads, photographed them, and studied their religions and languages. He had also collected plants, had examined the ruins of ancient civilisations, had estimated the volume, speed, and depth of the strange rivers that lost themselves in deserts where the wild horse and the wild camel still range at large.

It was only by the happiest chance that the young explorer did not perish in the desert. After trying to reach the top of Mus-tagh-ata, or the Father of the Ice Mountains, which is the loftiest height of the Pamirs, towering up 25,600 feet, and overlooking the barren wastes of Central Asia, Sven Hedin came down, with his strength broken and his eyes bandaged, and sought a warmer climate. Four times he attacked the ice mountain, but only climbed 20,660 feet, and was beaten back by tempests. He then turned to the Takla-

makan desert, eastward of the Mus-tagh-ata, and entered the awful sea of sand, rolling in yellow waves 100 feet to 200 feet high. It was very slow travelling, and the camels broke down for want of water. Some had to be shot to put an end to their sufferings, and Hedin and his native followers trudged on in search of the Khotan River. It was on May 1, 1895, that every drop of water was spent, and the camp of death was pitched in the heart of the unexplored wilderness.

Like his men, Hedin grew delirious with thirst, and thought he was sitting in the rose garden of a merchant's house in Bagdad, with a fountain of water playing beside him. This indeed had happened—nine years before! He lay for a day with wild fancies running through his head; then, as he says, something like a miracle occurred. He sprang up, resolved that he would not die. He set out with one man who could still walk, and on May 5 reached a forest, and chewed some tamarisk leaves. But no water was found, and in the evening the native fell and could not rise. Hedin fell too, but kept on, partly crawling and partly staggering on his feet.

At the end of the forest he found the river. It had dried up; its bed was as parched as the desert around it! Still, Sven Hedin would not lie down and sleep, and never wake. Steeling himself by the strongest effort, he kept awake, and after going about a mile and a half he found a pool of water. He drank six pints of water, and, far from feeling any ill effect, his energy returned and his pulse beat faster. Filling his long waterproof boots with water, he went back to his native companion, and saved his life. Another member of the caravan was saved by some shepherds.

Undaunted by these terrible experiences, the Swedish explorer adventured again into the desert of death, crossed it in another direction, and discovered some ancient cities buried in the sands. These were afterwards excavated by Dr. Aurel Stein. Sven Hedin went on to the desert of Gobi, and settled some problems connected with it, and reached Peking after spending more than a thousand days in the heart of Asia.

Written in an uncommon and vivid style, the tale of his travels at once became one of the classics of exploration.

In 1899 he returned to the desert, where he nearly perished, and surveyed the great River Tarim, that flows along the edge of the wilderness, and sinks at last in the sands. He then went on to Tibet, and returned to Europe in 1902. Four years later, the passion for adventure again led him into the unknown regions of the world. He went overland to India, intending to cross the frontier and explore Tibet, but the British authorities could not permit him to do so. So he set out from Kashmir, ostensibly for Turkestan, but suddenly turned into the forbidden land. The Tibetans tried to force him to retrace his path, but he succeeded in exploring the southern part of the country, and interviewing the Tashi Lama, and investigating the hitherto unvisited sources of the Brahmaputra by 1907.

HENRY HUDSON

An Elizabethan in Quest of the North Pole

Henry Hudson, the great Elizabethan navigator, was possibly the son of a London

SIR SVEN HEDIN

alderman. But all that is known certainly about his early life is that he was a citizen of London, had a house there, and was bred up in the service of the Muscovy Company. He emerges into the clear light of history in the spring of 1607, when he fitted out a cock-boat, called the "Hopeful," and set forth from Greenwich on May 1 to discover a passage to China across the North Pole. Hudson was not unaware of the perils and difficulties of such a voyage, for the result of Barentz's fatal attempt was known to him, and he had studied the best charts of his age. Yet with a crew of eleven

men and a boy, in a craft about the size of the smallest collier brig, he aimed at sailing right across the Pole to Japan; and as an actual achievement in Polar exploration he succeeded in making as careful a trial of the possibilities of this extraordinary voyage as has ever been done in modern times.

Taking his little son with him on the voyage, he sighted the east coast of Greenland on June 13, 1607, and continued along a northerly course for nine days. In so doing he discovered a large stretch of new land, that he named "Hold With Hope." Then, steering north-easterly along the edge of the pack-ice, he came to Spitzbergen, and discovered more new land there. Turning back, he attempted the magnificent feat of sailing round the unknown north end of Greenland, and returning to England by Davis Strait, but the ice blocked him. After discovering a lonely island that is now improperly named Jan Mayen, after a Dutch skipper who saw it some years later, Hudson returned safely to the Thames on September 15, 1607. Both from a geographical and a commercial point of view his voyage was important. He reached almost as high a latitude as Scoresby did two hundred years afterwards; he discovered new lands in Greenland and Spitzbergen; and he was able to bring to the Muscovy Company news of a great whale-fishery that was richly exploited for two hundred years.

It was no doubt owing largely to this practical success that Hudson was provided the following year with the means of fitting out a second expedition. He sailed from the Thames on April 22, 1608, and reached the coast of Novaya Zemlya on June 26. But he found the ice barrier impenetrable by his small craft. After examining the coast of the wild Arctic island where Barentz had perished in a similar attempt to sail round Siberia to China, he turned his vessel southward, and arrived at Gravesend on August 26. As there were no commercial results from his second Polar voyage, the Muscovy Company declined to finance a third expedition. So Hudson entered the service of the Company of Amsterdam, and received in 1609 the command of a vessel in which he intended to follow the track of Barentz, and further extend the exploration of the Siberian route. But when he reached the Arctic seas his crew were disheartened by the cold and ice, and they threatened to mutiny if Hudson did not turn back. They were, in fact, already in open rebellion, and Hudson was compelled to listen to them.

In order to pacify the mutineers, he proposed to them to seek for a passage to China through Davis Strait, and with some trouble he got them to agree to this course. He landed on the American coast, replaced his foremast, which had been broken in a storm, and profited by the occasion to start trading in furs with the natives, but his undisciplined sailors made the natives angry by their exactions, and Hudson was compelled to set sail. He continued to follow the coast northward, and on August 3, 1609, as he passed by Hudson River, his provisions began to run short, and his mutinous crew compelled him to return to Europe. He reached Dartmouth on November 7.

In the following year, 1610, Hudson tried to renew his engagement with the Dutch Company, but the terms they offered were so poor that the famous navigator approached the English Company again. His old masters were willing to fit out a ship for him, but for some reason they insisted that he should take as an assistant a skilled seaman named Coleburne. Hudson was mortified by this proposal, but he pretended to agree with it, and Coleburne entered the ship. Hudson asked him to take a letter to the Company, and while the man was gone he sailed away to the north of America. The crew, however, were angry at his treatment of Coleburne, and they formed their first conspiracy against him, which Hudson repressed on June 1. He passed Frobisher's Strait, and sighted the land of desolation of Davis. Then, entering Hudson's Strait, he burst into Hudson's Bay, and spent some time examining the entire western coast.

In September one of his officers again tried to excite revolt against his rule. Hudson was compelled to strip him of his rank, but this act of justice only exasperated the sailors. In the early part of November, Hudson reached the extremity of the bay named after him, fixed on a spot to winter in, and drew his ship up on dry land; for though he had left England with only six months' provision, he was resolved to face the Arctic winter rather than give up the search for the North-West Passage. Happily, his crew were able to kill a great number of birds, and so, though their rations were scanty, they did not have a very distressing winter. But when spring came and the ice cleared away, and Hudson prepared to sail his ship, he found that the sailors were resolved to get rid of him. Undisturbed by the conspiracy, the brave navigator distributed to each man his share of biscuit and paid each the wages due, and waited for the

THE LAST VOYAGE OF HENRY HUDSON, AS PAINTED BY THE HON. J. COLLIER

outcome of the successful conspiracy. He had not long to wait. The crew seized their captain, his son, and seven men who took his part, put them on board a boat without arms, provisions, or instruments, and left them to an awful death on June 23, 1611. It was one of the foulest deeds in the history of English seamanship. The murderers who survived the return voyage to England do not seem to have been punished for the crime. Perhaps the Muscovy Company resented the trick that Hudson had played them in regard to Coleburne, and did not at once try to arrive at the truth of the matter.

COMTE DE LA PÉROUSE

A Tragedy of the Port of Lost Ships

Jean François de Galaup, Comte de la Pérouse, was born near Albi, in the French department of Tarn, on August 22, 1741. The most distinguished of French navigators was early notable for his bravery in the navy of France. He fought with gallantry

against England as a mere youth. He was taken prisoner by Hawke when eighteen, but lived to regain his freedom and to play havoc with British possessions in Canada, and to capture in Hudson's Bay a couple of British forts. But it is as a navigator that he is of importance to us and dear to France.

To her he represents one of her great might-have-beens. She has, in imperial concerns, two regrets. One is that the Peace of 1783 put an end to the expedition of Barras to India, which, they say, but for that "untoward" treaty, would for ever have ended British dominion in India. The other is that practically all the work of La Pérouse should have perished with him.

LA PÉROUSE

The passion of the French for the soil on which they were born kept them too long at home. Spain, Portugal, Holland, and England had been out into the highways and byways of the world's waters and had planted their flags, but France had remained shut up to a great extent within her own borders, except when she was striding across a bloodstained Europe. La Pérouse was sent out to garner everything in the way of territory lying unclaimed, and specially to lay hold of what is now Australia. It is pleasant to reflect that, although his mission was actually hostile, in this particular, to Great Britain, it was accomplished, so far as it went, without recourse to warfare.

When the American War broke out, Louis XVI. decreed that his ships should everywhere show respect to those of Captain Cook; and when the time came for renewal of hostilities, Sir Joseph Banks so actively bestirred himself that a similar courtesy was extended by Great Britain to La Pérouse, "should he be still alive." The probability is that the valiant navigator's bones were at the time bleaching in some sea-steeped coral cave. The intention, however, was chivalrous, and in amiable contrast to the treatment meted out on both sides to other peaceful citizens of the deep, notably in the case of Matthew Flinders, who was arrested by France, kept prisoner in a French garrison for six years, his magnificent Australian surveys being stolen, and preparations made to turn his work to wrongful account by making French possessions of all the lands that his notebooks described.

It was in 1785 that La Pérouse set sail with two vessels from Brest to circumnavigate the globe. He was sent out by the French Government, in answer to a wave of enthusiasm for exploration and empire, stimulated by the magnificent work achieved by Cook. He was instructed so to shape his policy as to add to the common knowledge of geography, astronomy, natural history, and philosophy, and to collect accounts of manners and customs in the strange places at which he was to touch. He took with him astronomers, naturalists, philosophers, skilled artificers, and mechanics, and the finest equipment that France could furnish in the way of scientific instruments for determining the differences in gravity at various points, the true proportion of the equatorial to the polar diameter of the earth. He was to inquire also into the possibilities of the fishing and fur trades of North America, and to make the North-West Passage, which Cook had failed to achieve.

After doubling Cape Horn and exploring the coasts of California and Macao, he made important discoveries from China to Kamtchatka. His name, bestowed upon the strait dividing the island of Saghalien from Yezo, showed that the long-sought continent did not exist in that latitude. From Petropavlovsk he sent home by the overland route a missive telling the story of his voyage to date, and that report was in due time published as "Voyage Autour de Monde." Sailing from Kamtchatka, he reached Botany Bay, ready to hoïst the French flag. But he found the British already in possession; so, after an exchange

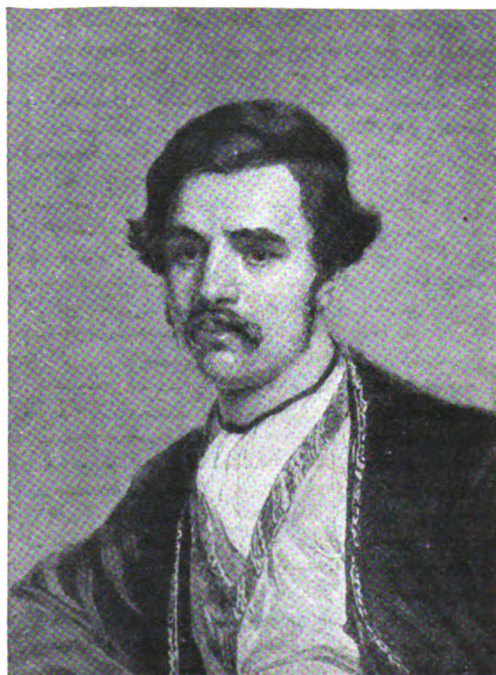
of hearty compliments with the friendly enemy, he set sail again for home.

That was in February, 1788, and he was never seen again—neither he nor his crews. Mystery enveloped captain and crews as complete and tragic as that which was afterwards to envelop the Franklin expedition to the North. Though separated by time, the lines of the two men crossed. Franklin's first long voyage was to the Australian coast, where La Pérouse was last seen. His first footing in North America was at Fort York, in Hudson's Bay, by the capture of which La Pérouse had first gained fame. Many ships in many seas sought the unfortunate La Pérouse. Sir Joseph Banks, to whose generous nature the tragedy greatly appealed, had benevolent sea-dogs on the look-out in every ocean and sea and strait. Nearly forty years passed before the cloud of mystery was dispelled. Then, in 1826, Captain Peter Dillon found two dismal wrecks upon a coral reef off Vanikoro, north of the New Hebrides.

When Franklin was governor of Van Dieman's Land, he caused a monument to be erected at Port Lincoln, at the entrance to Spencer Gulf, which Flinders, his kinsman and old commander, had discovered. And two years after the unhappy fate of La Pérouse was made known, Dumont d'Urville, with pious affection, journeyed to the scene of that disaster, and paid similar homage to the gallant and skilful navigator whose life had been surrendered there in the cause of knowledge. How the ships went down can, of course, only be surmised. Both were shattered on the same reef, and all must have perished in company. La Pérouse was the first and last of the great French navigators, and with him died the wave of French enthusiasm for travel beyond the unknown seas. The date of his death cannot, of course, be definitely known, but it is almost certain to have occurred in the year 1788.

SIR HENRY AUSTEN LAYARD
The Man who Found a Lost World

Henry Austen Layard, the discoverer of Nineveh, was born in Paris on March 5, 1817. Parisian by birth, partly Italian by education, English on his father's side, Spanish on his mother's, Layard certainly possessed the qualities and imagination necessary to befit him for the romantic quest in which he was destined to engage. The suggestion of mixed nationality once proved a disadvantage when he sought the suffrages of an English constituency, where the mention of a foreigner was anathema. Layard, however, turned the tide in his favour by reminding his audience that if a man happened to be born in a stable he would not be described as a horse.

It was the reading of the "Arabian Nights" that determined Layard's career. "To them," he says, "I attribute that love of travel and adventure which took me to the East and led me to the discovery of the ruins of Nineveh. They give the truest, most lively, and the most interesting picture of manners and customs which still existed amongst Turks, Persians, and Arabs when I first mixed freely with them." It was the same book that sent Sir George

SIR HENRY LAYARD

Taubman Goldie to his great work in Africa in our own day.

But there were few fairy visions in the preparation for life which Layard had to undergo. His father articled him to a relative, a lawyer in London, who, although he entertained with lavish generosity, was none too liberal with his romantic nephew. At his house Layard met Disraeli, who wrote a considerable part of "Vivian Grey" under that roof, and roughly snubbed the youth, who was at that time disposed to admire him as a traveller in the fabled East. It was at his uncle's table that Layard heard his host called away from dinner to rescue Disraeli from a debtors' prison.

The drudgery of a lawyer's office was hateful to young Layard; and often enough at night, when his uncle imagined that he was grinding away at his law-books, he was quietly entertaining poor Polish refugees in his rooms at a modest supper of sprats. The fare may have been humble, but the talk was exalted—of thrones overturned and tyrants deposed, and downtrodden humanity redeemed from bondage. Between whiles Layard, thanks to the assistance of a moneyed friend, managed to see something of the more or less untrodden ways of Europe, and each experience more and more whetted his appetite for travel. He was indeed a born nomad. During a holiday, when returning up the Thames from Ramsgate, where he had just left his mother, he saw a steamer advertised to sail for St. Petersburg; and, just as the sight of a cake of soap or a razor could inspire in another happy genius the desire to shave, so this picture fired Layard with the resolution to "do" Russia and Sweden and Norway. He had just enough money to cover the route by living modestly and travelling "third"—and this he did, with adventures enough to fill the average traveller's diary.

Just when Layard should have been entering for his final legal examination, his uncle arrived from Ceylon, and to Ceylon he would go, to practise law, or plant coffee, or something else, but anyhow to Ceylon. He passed his examination, drew from his mother £300, and arranged that a similar sum should be handed to him upon his arrival in Ceylon, but he never called for it. Of course, he could not go by sea, or he would not have been Henry Layard; he would go overland, through Europe, Central Asia, and India! And, setting out to make his fortune as a lawyer at the Ceylon Bar, his heart was secretly leaping at the thought that at last he would visit the scenes of his beloved "Arabian Nights." It did not matter that England and Persia were apparently on the eve of war; he meant to cross the country and explore the mountains of Luristan, to enter India by way of Afghanistan, and traverse the entire peninsula on foot. He set out with a companion in 1839, and gratified his heart's desire by rambling hither and thither in Persia and Turkestan and elsewhere, and, instead of Ceylon, turned up at—Constantinople. Ceylon, like the English Bar, had gone by the board.

During his wanderings in Asia Minor he had formed a plan for excavating the buried glories of Mesopotamia; and, enlisting the sympathy of Sir Stratford Canning, then British ambassador at Constantinople, he was enabled to execute his plan. His excavations, which were among the most romantic, the most hazardous, and the most successful ever carried out, turned back the pages of a closed volume of history. They gave back Nineveh the mighty to the world; they revealed Calah, as to which we learn from Genesis x.: "Out of that land went forth Asshur, and builded Nineveh and the city Rehoboth, and Calah." He unearthed the wonders and splendours of Babylon, and bridged the gap which divided Nebuchadnezzar and Sennacharib and the terrible heroes of Old Testament times from the nineteenth century.

It was romantic, breathless work, which hardly any man but Layard could have achieved—Layard the daring, the persuasive, the persistent, the tactful. He brought to England noble specimens of the colossal sculptures of these old-world cities, carved to gratify the artistic ambitions of Sardanapalus, or to match the grandiose moods of Nebuchadnezzar or Sennacharib. He gives us the writings that these kings knew; their signatures, their proclamations, their vainglorious records of wars against Jerusalem; the reports they or their officers received on such diverse matters as the sale of slaves, the gathering of armies and ordering of campaigns, eclipses of the sun and moon, the signs of the zodiac, the appearances of clouds, rain, and storms; the sale and letting of property, loans of barley, the rewards claimed by Babylonian detectives for the recovery of golden tablets stolen by workmen from the temple. It is all as immediate and realistic as if the events related not to an age thirty, forty, or more centuries ago, but to the affairs of a kingdom of today.

The glories of our Babylonian and Assyrian galleries at the British Museum attest the success of the efforts of this intrepid and talented man, and of the successors whom he inspired. When Layard began, spade in hand, to delve into the buried mystery of past ages, there did not exist in Europe sufficient Assyrian relics to fill a handcart. The possessions of the British Museum were enclosed in a case three feet square, and into that was packed all that remained not only of the great city of Nineveh, but of Babylon itself! It was thought, indeed, that Nineveh had perished utterly, palaces, sculptures, records and all; that it had vanished like the Cities of the Plain. To Layard was left the task of showing that the mountainous heaps of rubbish

frowning upon the desert, the grass-grown mounds on which in spring the wandering Arabs pitched their murky tents and pastured their lean herds and flocks—that these mounds contained the city of tradition, and that here were hidden the long-sought relics which proved tradition accurate.

Layard's work is referred to in pages 3977-79 of the present work. We may recall here one famous tableau, the finding at Nimrod of the first winged bull. "I was returning to the mound when I saw two Arabs urging their mares to the top of their speed. On approaching me they stopped. "Hasten, O Bey,' exclaimed one of them—'hasten to the diggers, for they have found Nimrod himself. Wallah, it is wonderful, but it is true! We have seen him with our own eyes. There is no God but God.' And, both joining in this pious exclamation, they galloped off, without further words, in the direction of their tents."

He descends into a great trench which had been cut. "The Arabs withdrew the screen they had hastily constructed, and disclosed an enormous head sculptured in full out of the alabaster of the country. They had uncovered the upper portion of the figure, the remainder of which was still buried in the earth. I saw at once that the head must belong to a winged lion or bull. It was in admirable preservation. the expression was calm yet majestic, and the outline of the features showed a freedom and knowledge of art scarcely to be looked for in the works of so remote a period. I was not surprised that the Arabs had been amazed and terrified at this apparition. It required no stretch of imagination to conjure up the most strange fancies. This gigantic head, blanched with age, thus rising from the bowels of the earth, might well have belonged to one of those fearful beings which are pictured in the traditions of the country as appearing to mortals, slowly ascending from the regions below."

Layard, whose works on his travels, explorations, and excavations are among the most fascinating in the language, afterwards had a long political career, and was ambassador at Madrid and Constantinople before retiring to Venice, where, in a beautiful palace, he made a superb collection of pictures, wrote delightfully on art, helped to revive some of the ancient glories of Venetian crafts, and was the host of princes and statesmen from many lands.

He died in London on July 5, 1894. Lady Layard, a gifted and charming woman, survived him until November 1, 1912; and her salon in Venice was one of the most famous in Europe, at which the poorest artist or man of letters was as cordially welcome as the haughtiest monarch or the most exacting recent celebrity.

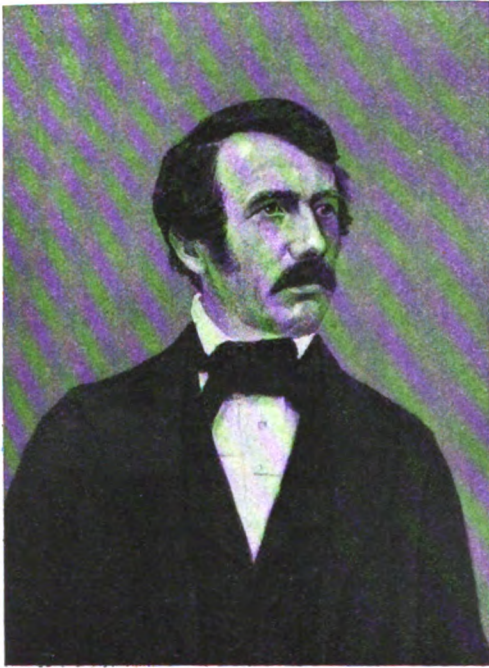
DAVID LIVINGSTONE

The Opener-Up of the Dark Continent

David Livingstone was born at Blantyre, near Glasgow, on March 19, 1813, the son of poor, thrifty, worthy Scottish parents, who, when he was ten years of age, had to put him to work as a piecer in a cotton factory. Some men have education thrust upon them, others have laboriously to seek it; Livingstone was one of the latter. Out of the scanty pocket-money his half-a-crown wages allowed him he bought a Latin grammar, and studied it diligently even while at work, setting up his book on the spinning-frame to snatch glimpses at its contents as he toiled. He worked fourteen hours a day at the mill, yet managed to attend a night-school, and would read for an hour or more after his return home. It was good intellectual training, but he was a physical culturist as well, for, with his brothers, he roamed far and near, botanising, and otherwise studying Nature.

When he was nineteen he became a cotton-spinner, and his extra wages enabled him to put into practice a scheme of studying for the calling of a medical missionary. To this end he toiled with great assiduity at the factory for half the year, and for the rest was a student at Glasgow University. There he met several young men destined to achieve fame—Murchison, Young the discoverer of paraffin, Lyon Playfair, and others. They all helped to put him in the way that he should walk, unconsciously preparing him for the life that was to follow. Livingstone and Playfair naturally drifted apart, but in later years they corresponded on scientific subjects, and Livingstone, on one of his visits to England, called on his old friend, who had had not the least idea that his correspondent was the impecunious student of other days.

When Mrs. Livingstone returned from Africa to Scotland she went straight to Playfair's house in Edinburgh, where he was entertaining a numerous company at dinner. Travel-stained, and clad just as she was when leaving Africa, she was ushered into the dining-room to explain that her children were somewhere in Edinburgh, and she was anxious to find

them that night. All she knew was that they lived in the longest street in the city. Playfair, to whose chivalrous nature the adventure appealed, left his guests, sallied forth into the streets with her, employed a batch of porters to divide the street between them, calling at every house and asking for the children of Livingstone. The children were found, and the delightful, unconventional woman took it as a matter of course. She herself would have done a similar thing in Africa for Playfair. Of such are the ways of these demi gods and goddesses of the untrodden paths, and such the manner in which the Playfairs of the world delight to serve them.

DAVID LIVINGSTONE

It was the fame of this noble woman's father, Dr. Robert Moffat, that drew Livingstone, at the end of his student course, to Africa. He sailed in 1840, and proceeded inland to Kuruman, travelled far and near in Bechuanaland, then founded a mission in the valley of the Mabotsa. Africa, in spite of its Portuguese, British, and Boer settlements, was still, as to the north, a Dark Continent indeed, and it fell to Livingstone to carry the torch of knowledge into its gloomy depths. The transition from missionary to traveller came about in this wise. He found that, wherever the foot of Portuguese or Arab had fallen, the making of slaves was the staple industry. Terrible misery prevailed wherever he turned. He saw that in order to suppress this traffic a definite war by peaceful methods must be prosecuted. The natives must have an organised commerce. For that they must have well-mapped routes by which they themselves could travel in safety to carry their wares to the seaboards of the Atlantic and Pacific, and by which white men could advance into the interior to buy and barter. He set himself to find the paths, to master the languages, and to teach Christianity where he learned dialects and routes. To this end, Livingstone, although always a great Christian teacher in Africa, severed his connection with the society by which he had been sent out, to become an unfettered pioneer.

It was with the definite object of finding a transcontinental route that, in 1849, he began his serious travels. Having crossed the vast Kalahari desert, he discovered Lake Ngami, which, then a sheet of water fifty miles in length and from ten to twenty broad, seemed to him, after his desert days, a find of prime importance. Today Ngami is simply a reed-grown swamp except in the rainy season. But the discovery was important in a sense that he did not realise, for it gave a direct aim to his travels, and led him on to the discovery of the Zambesi in the very heart of Africa. Previously this mighty river had been supposed to rise near the coast; yet here was the Zambesi, in the dry season, a deep, swift-flowing river, from three hundred to six hundred yards in breadth. "We thanked God for permitting us to see this glorious river," he wrote, for here, in the mysterious depths of this inscrutable land, was evidence of one certain highway to the eastern seaboard. Without staying now to explore it, he bore north-west, for it was to the western seaboard that his countrymen with trade must come. Every mile traversed, he felt, carried him nearer his goal, and that goal was the destruction of the slave trade by the substitution of legitimate commerce over a route which he was now piecing together. He reached Loanda, on the coast of Portuguese West Africa, in 1854, desperately ill, "a mere ruckle of bones," as he said, but set out upon the return journey the same year, and renewed his exploration of the Zambesi and Kuanza basins.

On the way up he had stopped at Lake Dilolo. He returned thither, and found

various tributaries of the Congo flowing northward, with the Zambesi flowing southward. Lake Dilolo sends a feeder to each river system, so linking the Atlantic with the Indian Ocean. Livingstone was led to a correct estimate of the formation of Central Africa, but of course he could not make even a guess as to the details of the great river systems of the continent, and we have him writing, only a few months before his death: "As to this Nile source, I have been kept in perpetual doubt and perplexities. I know too much to be positive. Great Lualaba, or Lualluba, as Manyuema say, may turn out to be the Congo, and the Nile a shorter river after all. The fountains flowing north and south seem in favour of it being the Nile. Great westing is in favour of the Congo. . . . I am even now not at all cocksure that I have not been following down what may after all be the Congo." Which was exactly what had happened. The extract is worth recalling here, midway through his immortal journey across the continent, made possible by his genius as a geographer.

A MEMORIAL TO DAVID LIVINGSTONE IN THE HEART OF AFRICA

There now awaited the discovery which, more than all the rest of his labours, has for nearly sixty years fascinated the public imagination. He was the first white man ever to look upon the Victoria Falls. Here the river, 1000 yards broad, leaps 400 feet sheer into a huge fissure in the earth's surface, and, shut in by towering black basaltic cliffs, boils and leaps through a channel which has suddenly narrowed to a score of so of yards. Lower down the river were the Portuguese, who have been in occupation almost since Da Gama named the Zambesi the "River of Good Signs," but they had never heard of these falls, the most stupendous in the world.

Livingstone reached Quilimane, Portuguese East Africa, in May, 1856, having for the first time in history crossed Africa from west to east. He had worked his way, in the course of fifteen years' journeyings, from Cape Town up through Bechuanaland, westward to Loanda, and then eastward to the Indian Ocean. He had already married Mary Moffat, and she, with immense heroism and self-sacrifice, had accompanied him, with their increasing family, on a considerable part of his travels.

Livingstone returned to England, published a book, was fêted and honoured, and then set out on a Government expedition further to explore the Zambesi.

Resuming his wanderings in March, 1858, he made careful investigations along the Zambesi, the Shiré, and Rouma; discovered Lake Nyassa (out of which the Shiré flows) and Lake Shirwa, a lesser body of water 45 miles south-east of Nyassa. His devoted wife died during this expedition, and was buried at Shupanga (April, 1862). Sir John Kirk, who accompanied Livingstone on this expedition, and was at the deathbed, still survives. Livingstone's heart was broken by the blow. "For the first time in my life I feel willing to die," he wrote. But his work had to go on. The Government recalled the expedition, but at his own cost he explored the northern banks of Nyassa, proceeding by his own little steamer to Bombay, to return thence to England, after an absence of six years. In his second book the fire of his wrath blazed out against the abominations of the traffic in slaves carried on by the Portuguese. And, long before Cecil Rhodes, he was planning homes for white men in the African wilds.

His third and last journey was undertaken in 1866, at the instance of the Royal Geographical Society. Burton, Speke, Grant, and Baker had recently added Lakes Tanganyika, Victoria Nyanza, and Albert Nyanza to the map, but still the mystery of the Nile's source and of the watershed of Central Africa was not solved. Livingstone was to make another effort. He discovered Lake Bangweolo. Here the Chambese flowing into it, and the Luapula flowing out of it, constitute the headstream of the Congo.

All his plans miscarried on this expedition. Supplies sent up from Zanzibar were intercepted; those that he deposited were nearly all stolen, and when Stanley, sent out to seek him, came to his aid, he was all but dead. Re-invigorated by the supplies that his rescuer carried, Livingstone, left alone, carried on his work for another year, but his constitution was utterly broken, and he was borne, a dying man to Ilala, a village on the south shore of Bangweolo. There on the morning of May 1 (or May 4), 1873, he was found by his attendants, dead, in the position in which he had knelt for his last prayer.

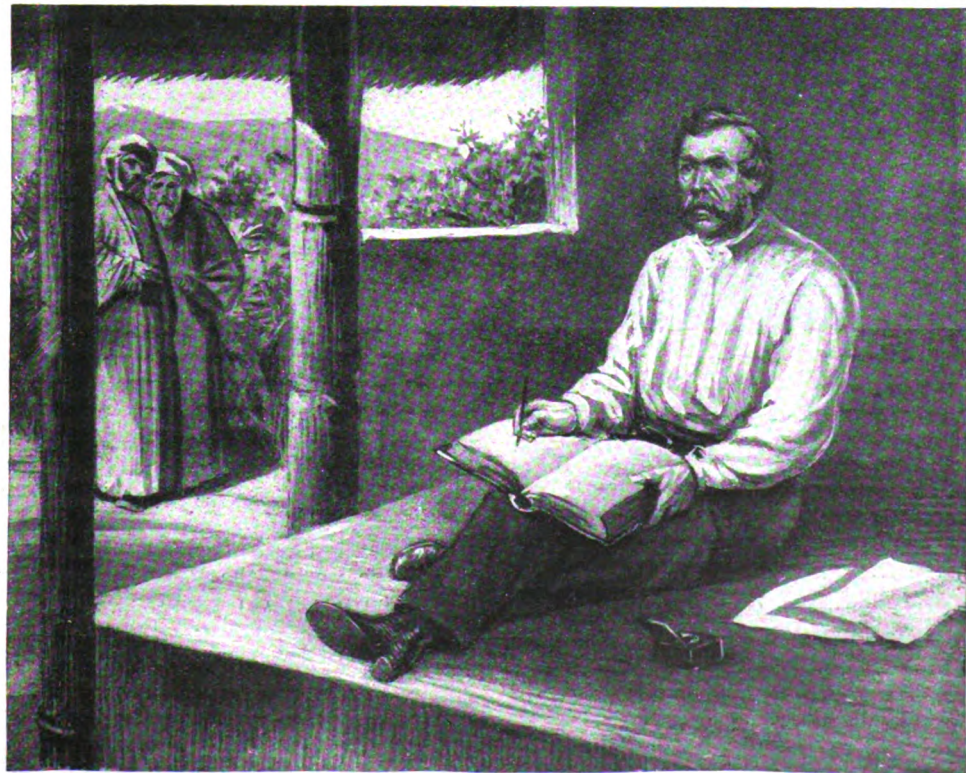
Eleven years before, with the remains of his wife newly committed to the earth, he had written of his own end: "I have often wished that it might be in some far-off, still forest." His wish was fulfilled. His faithful servitors buried his heart beneath a giant tree in Ilala, and, by a journey which will live for ever in the annals of heroic travel, bore his body to the coast. It lies now in Westminster Abbey, with a memorial stating: "Brought by faithful hands over land and sea, here rests David Livingstone, missionary, traveller, philanthropist." His last written message to the world was: "All I can say in my solitude is, may Heaven's rich blessing come down on everyone—American, English, Turk—who will help to heal this open sore of the world!" He did not toil and pray in vain. He laboured for the saving of souls, for paths in the wilds, for trade in everything but flesh and blood. His son Tom cried: "We will go from Cairo to Cape Town, and preach a railway and call it Livingstone's line." The trade and the line have begun, and slavery, which Livingstone abhorred, has ceased.

FERDINAND MAGELLAN

The First Man to Sail Round the Earth

Ferdinando Magalhaens, usually known as Ferdinand Magellan, was the son of a Portuguese gentleman, and was born about 1480 at Villa de Saborosa, in Tras os Montes. Brought up under King John II., he studied particularly mathematics and navigation—the science by which Prince Henry the Navigator had made his country the leader in civilisation in the fifteenth century. Throughout Portugal there was a zest for maritime expeditions and discoveries; and Magellan, like many other poor noblemen, took to a sea life, and in 1505 sailed for the Indies, and assisted in the sacking of Quoila. He went as far as Sofala, and, returning to the Malabar coast, distinguished himself by his skill and bravery in the capture of Malacca. He took part in the expedition that set out in 1510 to seek for the famous Spice Islands, and in the archipelago of the Moluccas he seems to have obtained information that led him to undertake his famous voyage round the world.

On coming back to Portugal he searched through the Royal archives, and found the bull of demarcation by which Pope Alexander VI. had divided the spheres of discoveries of Spain and Portugal. It became clear to him that by this arrangement the Moluccas belonged to Spain. So he did not trouble about the matter, but went on active service to Morocco, where he was lamed for life in a fight at Azamor. On returning to Portugal he was unjustly treated by his king, who accused him of merely pretending to be wounded. This outrageous accusation angered Magellan, who was a man of high spirit and a fine

THE DISCOVERY OF LAKE NGAMI BY LIVINGSTONE, ACCOMPANIED BY HIS FAMILY

DR. LIVINGSTONE AT WORK ON ONE OF HIS BOOKS IN DARKEST AFRICA

sense of honour. He publicly renounced his rights as a Portuguese citizen, and took out letters of naturalisation in Spain, and henceforward devoted his whole life to serving the Crown of Castille.

The knowledge Magellan had won in Malaysia now became a weapon of vengeance against his unjust king. Arriving in Spain in 1517, he had an interview with the Emperor Charles V., and on March 22 of the following year an agreement was made between the emperor and the Portuguese captain. Magellan promised to find for Spain a new route leading to the very centre of the Spice Islands, which would damage the trade of Portugal, and the emperor undertook to pay all the expenses

FERDINAND MAGELLAN

of the expedition, on condition that the greater part of the profit should be his.

It is said that the Portuguese ambassador tried to have Magellan assassinated, and then fomented a rising against him. But, in spite of these troubles, Magellan set sail from San Lucar de Barrameda on September 20, 1519, on the first voyage that man had ever undertaken round the world. His fleet consisted of two ships of 120 tons each, and three vessels of smaller size. Four of the captains and nearly all the pilots were Portuguese, and there were 237 men in the fleet whose names have been handed down.

The fleet touched at Teneriffe, and here a quarrel broke out between Magellan and his second in command, Juan de Carthagena, which proved fatal to the expedition. Carthagena claimed the right to know the route that Magellan intended to take; but as this was a secret of great importance to the Portuguese captain, he refused to reveal it to his subordinate. While the fleet was detained by contrary winds and calms off Sierra Leone, Carthagena insulted his leader, and was put in chains, and then simply placed under arrest and guarded by one of the captains. The fleet steered then for Brazil, arriving at Rio Janeiro on December 13, 1519.

The Spaniards obtained a large quantity of fresh provisions from the Red Indians in exchange for looking-glasses, pieces of ribbon, and small bells. They sailed to La Plata, where De Solis had been massacred four years previously, and, coasting down Patagonia, Magellan arrived at St. Julian's Bay, where he prepared to winter. The country was so bare that he had to put the men on fixed rations, and the Spaniards began to murmur and revolt. The land seemed to them to stretch as far as the Antarctic Pole, and they regarded it as certain that no strait would be discovered leading to the Pacific Ocean.

Magellan resolved to die or to bring his enterprise to a successful conclusion. But though he managed to keep his fleet in order till the spring, on April 1, 1520, the partisans of Carthagena rose up in arms, and captured three of the ships and murdered one of the pilots. By quick, strong measures Magellan recovered the ships after some fighting, and put Carthagena and some other leading rebels ashore, and then set sail in search of a passage to the Pacific. One of his ships was wrecked in a violent storm, but on October 21, 1520, the Strait of Magellan was found; and after sailing for twenty-two days across a succession of narrow inlets the fleet emerged upon a sea of immense extent and great depth.

There were general rejoicings when the sailors at last found that their commander-in-chief had taken the right route. Magellan called the new ocean—one of the stormiest in the world—the Pacific, because by happy chance no tempest assailed him upon it for four months. But the privations endured by the crews were terrible. The biscuit was nothing but dust mixed with worms, while the water was foul and offensive. To save themselves from dying of hunger the sailors had to eat the mice infesting their ships. Many of them died

from scurvy. At last, after having sailed over more than twelve thousand miles without touching a single island, Magellan discovered, on March 6, 1521, three islands, which he called the Islands of Thieves, because the natives stole so many things from his ships.

About nine hundred miles from the Ladrones, Magellan made land at the Philippine Islands, and pitched two tents on the shore for his exhausted crews, and bought fruit and fish and vegetables from the natives in exchange for mirrors, combs, bells, and other trifles. He named the archipelago the St. Lazarus Islands, but this important group of lands was afterwards called the Philippines, after Philip of Austria, the son of Charles V. One of the kings of the islands came on board the Spanish ships. Magellan brought forward a Spanish soldier clad in complete armour, and in the presence of the king set three men to attack him with swords and daggers. Naturally their weapons did not penetrate the armour, and the native ruler was so impressed by the apparent invulnerability of the Spaniards that he and another native king and five hundred of their people consented to be baptised into the Christian faith.

Having destroyed all the idols, the explorer resolved to attack the chief of another island, Matan, who refused to recognise the authority of Spain. On April 27, 1521, he set out for the island with three longboats containing sixty musketeers, and thirty native canoes filled with native warriors. Rocks and shallow water prevented the Spaniards from beaching their boats, and a host of 1500 hostile islanders gathered along the shore to oppose them. The Spaniards leaped into the water, and for a while seemed like winning a victory, for their armour protected them from the poisoned arrows and spears of the islanders. But the natives at last took to aiming at the legs of the Spaniards, and Magellan himself was then wounded by a poisoned arrow. He gave the command for a general retreat, but the islanders flung themselves into the water after the Spaniards, and the retreat quickly became a wild flight. Several islanders surrounded Magellan in the sea, and slashed at his feet until he fell beneath the waves and was drowned.

A brave man and a daring navigator, who made his foreign and jealous crew admire him by sharing all their privations and bringing them at last to islands of tropical splendour and fertility, Magellan ranks next to Columbus in genius and enterprise. Had he been content to explore and return with a more powerful fleet, he would have accomplished himself the wonderful voyage round the world that he was the first of all men to undertake. But after he was killed a series of misfortunes fell upon his men. A large number of them were invited to a feast by the king who had been baptised, and then massacred. The crews were so reduced in number that they could not work all their ships, and had to burn one.

They sailed to Borneo, and exchanged presents with the rajah, and went on to the Spice Islands that Magellan had reached in his former wanderings. This practically completed the voyage, but the two remaining ships, the "Trinidad" and the "Victoria," were now becoming unseaworthy. The "Trinidad" began to leak badly, and had to put back to the Spice Islands. She fell into the hands of the Portuguese, and the three surviving members of the crew were imprisoned by the rival Power. The "Victoria," under the command of Juan Sebastian del Cano, who had embarked with Magellan as a pilot, and won his way to the front by his knowledge of navigation, was the only ship of the fleet that got back to Spain. Only by the greatest vigilance did Del Cano escape from the Portuguese at Cape de Verde Islands, and he arrived at Spain on September 6, 1522, with a crew of only seventeen men, almost all of whom were ill. Two days later he anchored before the mole at Seville, having accomplished a complete circuit of the world. Del Cano took a second fleet out to the Spice Islands, but died soon after passing the Strait of Magellan.

ADMIRAL SIR A. H. MARKHAM
Opener of the North Pole Gate

Admiral Sir Albert Hastings Markham, the hero of the Polar expedition of 1875, is the son of a naval captain, and was born at Bagnères on November 11, 1841. He entered the Navy at fifteen, and won the rank of lieutenant in 1862 by capturing a piratical Chinese junk after three and a half hours of unequal fighting. For three years he served as lieutenant of the "Blanche" on Australian waters, and he was then appointed acting commander of the "Rosario," and charged with the difficult duty of preventing the South Sea Islanders from being kidnapped for labour on the plantations of Queensland and Fiji. The law courts of Sydney were at the time

inclined to protect the kidnappers ; and the islanders, on the other hand, were apt to murder innocent white men by way of general vengeance for the wrongs done to them. The tactful and efficient manner with which Commander Markham quietened the natives and defeated the kidnappers in the New Hebrides and Santa Cruz groups marked him as one of the most promising of young naval officers.

His interest in Polar exploration was excited by an appeal that Admiral Osborn made in 1865 to all the active spirits of the Navy. But it was not until 1873 that he won an opportunity of learning ice-navigation. Admiral Osborn, who was then promoting an expedition of Polar discovery, thought that some naval officer should go to the Arctic seas in a whaler, and gain there the special experience needed in Polar exploration. He selected Commander Markham for the work, and in a voyage to the Gulf of Boothia the 'prentice explorer prepared for his future task.

In 1875 a Government Arctic expedition set out from Portsmouth under the command of one of the ablest of our navigators, Admiral Sir George S. Nares. The most important of the three ships, the "Alert," was in charge of Commander Markham. The "Valorous" returned to England from Disco, the "Discovery" was put into winter quarters as a supporting ship towards the north of Grinnell Land, while the "Alert" pushed on and discovered a channel between Greenland and Grinnell Land, and entered the Polar Ocean. The crew wintered at the most northerly point ever reached by ship. Autumn was spent in the practice of sledge-pulling, and parties were sent out to lay depots for exploring work in the spring. But it quickly grew cold, and eight men were frost-bitten, in three cases amputations being necessary. The sun was absent for 145 days, and the lowness of the temperature was more than had ever before been experienced. But the crew were in good health when daylight broke once more.

On April 3, 1876, Commander Markham left the "Alert," with fifty-six officers and men, to make a dash across the frozen Polar sea towards the Pole. The larger number of the sledging party were only helpers, and after going a stated distance they turned back, so as not to diminish the store of provisions. Two boats were carried in case open water should be found. The ice was indescribably rugged, and most of the time was occupied in making a path with pickaxe and shovel for the sledge-pullers. One day the party was only able to travel three-quarters of a mile. The labour and power of endurance needed were superhuman. Being only human, Commander Markham and his party were taxed beyond the utmost of their ability. On May 2 scurvy broke out; and, with swollen limbs and discoloured faces, the brave fellows struggled on through a blinding fog over hummocks of ice twenty to thirty feet in height. Five days afterwards the men began to break down, and had to be pulled along on sledges. On May 10 nearly a third of the party was unable to walk, and only thirty days' provisions remained for a return journey over a distance that had taken forty days when everybody was fresh and in good health.

So Commander Markham arranged for a couple of days' rest. While most of his men got in their sleeping-bags, he bored through the ice, and found it was only 64 in. thick, with water below 426 ft. deep. He collected there some small crustaceans and minute organisms, and on May 11, 1876, walked out as far north as he could go, and planted the Union Jack 399½ miles from the Pole. It was the farthest north at the time, and, what is of more importance, it opened the right road to the Pole by which Peary afterwards profited. Had it not been for the outbreak of scurvy, a much greater distance would have been covered. As it was, only five men out of seventeen were able to walk back to the ship, and they would have perished trying to save their comrades had not Lieutenant A. C. Parr made a magnificent march of twenty-four hours, reached the "Alert," and sent out a rescue-party.

Commander Markham was promoted captain on his return to England, and after serving for a considerable number of years on the Pacific was made captain of the Torpedo School at Portsmouth. As rear-admiral, in 1892, he was second in command of the Mediterranean Squadron when the flagship of his commander-in-chief collided and sank with four hundred of her crew. In 1901 Admiral Sir A. H. Markham was promoted commander-in-chief at the Nore. He is the author of a series of interesting books, dealing mainly with Polar explorations, and including a record of a trip he made in a cutter in 1879 to study the Barentz Sea approach to the Pole. He found steam-power was necessary to get well through the ice zone, and pointed out a possible route for a sledging expedition, which the Duke of the Abruzzi afterwards adopted with advantage.

SIR GASTON CAMILLE MASPERO
Who Dug Up an Ancient Civilisation

Gaston Camille Charles Maspero, one of the men who have dug up ancient Egypt from the sands, was born, of Italian parents, in Paris, June 23, 1846. While he was being educated at the Lycée Louis-le-Grand, he saw in a school-book an illustration of Egyptian hieroglyphs. He was fourteen years old at the time, and the mysterious signs so touched his imagination that he resolved to learn what they meant. He bought some books on the subject, and without help from anyone mastered the obscure literature of ancient Egypt, while continuing his ordinary course of study at school. When he entered the Ecole Normale he had made himself in his leisure time a first-rate Egyptologist. Naturally, his fellow-students were amazed at the unusual and difficult learning, self-acquired.

In 1867 some of them were dining with their professor, and Mariette, the most famous of Egyptian excavators, was present. The lads began to speak of their comrade who had taught himself to read the hieroglyphs. Mariette was interested, but incredulous. At first he chaffed the lads, for the sign-writing of the ancient Egyptians at that time was still often a puzzle to the best-trained scholars. But as the young Normaliens persisted in their statement, Mariette still jestingly gave them an inscription from the newly discovered monument to hand to their wonderful fellow-student. In a few days Maspero sent Mariette an admirable translation. The great Egyptologist was astonished. To test to the utmost the self-taught student, he forwarded to him a hundred mutilated lines of another new text, which had not only to be translated, but restored and completed. In a week Mariette received the completed text and the translation. It was so good that he published it, together with Maspero's first essay, in a scientific periodical.

Naturally, Maspero became the most famous student of the Ecole Normale. Though he should have remained another year to complete his ordinary course of studies, one of his professors recommended him to a literary crank in Montevideo who wanted a scholar to assist him in a work he was publishing on the Quichua language of Peru. The man had written a book to prove that this Red Indian tongue was really related to the ancient Sanscrit of India. Maspero, of course, could not help him in substantiating this impossible idea, but he got his book into shape, and in so doing extended his own knowledge of the civilisations of the Orient, and returned to France better off than when he set out for South America. He was back in Paris in 1868, and attracted attention by publishing an Egyptian Hymn to the Nile from the text in the British Museum. The next year he received an appointment to teach the Egyptian languages at a first-rate school, and in 1874 he was made Egyptian professor at the College of France.

His career as an excavator began in 1880, when he was sent to Egypt as chief of a Government mission, which he developed into the famous French school of Cairo. Early in 1881 he succeeded Mariette as director of Egyptian excavations and antiquities, and began his work by labouring to preserve the important monuments that his predecessor had left in a rather neglected condition. Unhappily, a lack of money prevented him from undertaking any regular excavations, though he managed to recover a very important series of royal mummies stolen by Arabs from a burial site.

Things were so bad that a French newspaper opened a subscription to provide him with funds, and with the money thus obtained Maspero cleared some magnificent temples, and freed from the rubbish of ages other important monuments. Most of the time the director lived on a boat on the Nile, for the rooms allotted to him at the museum were uninhabitable. In the stormy days of 1882 he was at first thought to have been killed, but he returned to Paris when the country grew more disturbed, and resumed his duties as a University professor. But since 1889 he has again been working in Egypt as director of the excavations. Possessing the French talent for writing on abstruse subjects in a charming and instructive manner, he has published a series of fine books on the ancient civilisations of Egypt and neighbouring empires. Some years ago he was surprised to find that a folk-tale of very ancient times was still current among the modern Egyptians. It was the earliest recorded story in the history of mankind, and he had himself published a translation of it a long time before he heard it again from the lips of the natives. But just as he was thinking of writing upon this extraordinary example of oral tradition, stretching back almost to the dawn of civilisation, he discovered that his translation was the source of the modern version to which he had been listening!

WHEN LITERATURE HELD A PLACE OF HONOUR AT COURT WITH BEAUTY AND BREEDING

GOETHE AS MASTER OF CEREMONIES AT THE COURT OF THE DUKE CHARLES FREDERICK OF WEIMAR

CONTINUED FROM 4663 CONTINUED ON 4901

THINKERS

GOETHE

A Poet who Found Evolution by Insight

JOHANN WOLFGANG GOETHE, the greatest of all German writers, cannot be omitted from any list of men devoted to science, for it was one of the most enthralling interests of the later part of his life, and by his insight as a poet viewing life on the widest scale he arrived at a belief in evolution.

Goethe was born at Frankfort-on-Maine, August 28, 1749, the son of a lawyer. It was intended that he should be a lawyer, too, but his tastes lay in quite other directions. Educated first at home, afterwards at Leipsic University, and finally at Strasburg University, his life was a series of love-making episodes; and, indeed, this phase of his experience continued till he was nearing his sixtieth year. Before his twentieth year he was deep in poetry, lyrical and dramatic. By the end of his twenty-second year he had completed his first play, "Goetz von Berlichingen." His first novel, "The Sorrows of Werther," was not written till he was twenty-five. His novel "Wilhelm Meister," and his dramatic masterpiece "Faust," were written, with extensions, throughout his life—over a period of more than fifty years. It is not our concern to tell, even in outline, the story of his literary achievements. They belong to pure literature. But Goethe was not only a supreme man of letters; he was a practical administrator and man of science. Called to Weimar when he was twenty-six, he became an active public economist in the service of the Duke and the State. Except for travels, he lived at Weimar for the rest of his life, died there on March 22, 1832, and there he is buried.

Never was there a more all-round man. He revelled in every form of experience, and sought enlightenment through every kind of study.. Nominally, he was an advocate, but he also tried to be an artist; he was not only a dramatist, but an actor and a stage-manager. He was a profound critic, a roving philosopher, a brilliant social force; but here we are concerned only with his attitude towards science.

No scheme of philosophy can be found in Goethe's writings, but his mental attitude was a great lesson to his own day, and has remained a permanent lesson. He opened his heart and mind to all experience for what it was worth, rejecting nothing through narrowness and prepossession. Thus his attitude was that of the unpledged scientific inquirer. Sometimes his too great independence of judgment led him astray, and caused him to seek diligently to overturn authorities that he could not move, as witness his long and wholly unsuccessful attempts to combat Newtonian theories.

He began the study of science at Strasburg University, taking up anatomy and chemistry, with a penchant for alchemy. Later he continued his study of anatomy, and traced an evolutionary principle in the development of the human skeleton. Passing on to a study of plants, he tried to discover—though, of course, futilely—some single flower from which all others had been developed; and he pointed out that all the parts of a plant, except the stem and the root, are but modifications of the leaf.

He studied geology, but was unfortunate in taking Werner as his mentor. A great deal of time was devoted to the study of optics; and when he had passed his sixtieth year he published a theory of colours, in opposition to Newton, which has been by one consent rejected by the science of a later day. Goethe, as a matter of fact, was not equipped by education for some of the scientific inquiries on which he entered, and what he saw that was fresh and valuable he saw rather as a poet than as an investigator; but his spirit of eager, all-embracing interest —seen in one who was acknowledged as the master-mind of his generation—was a stimulus to all inquirers, and his recognition

of the principle of universal development prepared many minds for an acceptance of the more precise views later put forward by Charles Darwin and others.

SIR WILLIAM HAMILTON

Populariser of Scottish Philosophy

Sir William Hamilton was born on March 8, 1788, at Glasgow. He came of a distinguished family, for his father and grandfather were professors in Glasgow University. There the clever boy studied with great success, and then went to Oxford. He became an advocate, but was a philosopher by nature, and, though a keen controversialist, was wholly unsuited for legal practice. In 1821 he was appointed Professor of History in Edinburgh, but not until fifteen years later did he gain the Chair of Logic and Metaphysics, which was his proper subject.

Sir William Hamilton was a genuine, ardent, and unweary thinker, whom the gravest ill-health could not baffle, and his very considerable knowledge of biology, which his father and grandfather had taught, kept him near the lines of Reid's philosophy of common sense.

But, principally owing to his ill-health, he never presented his thought in an orderly and connected system, and it was thus exposed to the attacks of so logical and relentless a critic as John Stuart Mill, through whose "Examination of Sir William Hamilton's Philosophy" the older thinker is best known to-day. Shortly after his death, Hamilton's lectures were edited by Dean Mansel, and in that form they had some influence upon Herbert Spencer, in whose pages reference to them will be found. Hamilton's philosophy was described by himself as a "natural realism." Spencer proposed to supersede it by a "transfigured realism," which went further than Hamilton's and admitted the existence of an external world, while declining to grant that things are what they seem.

Hamilton owed too much to his Scottish predecessors and to Kant for us to look upon him as a very original thinker, but his work had an immense and most beneficial influence upon philosophy and the development of psychology, through the enthusiasm which he excited in his pupils, and the interest which he aroused in the ultimate problems of existence. He wrote, to some extent, upon other subjects, especially education, which has always been foremost in the minds of leading Scotsmen.

He died in Edinburgh on May 6, 1856.

GEORGE FREDERICK WILLIAM HEGEL

The Greatest of the Idealists

George Frederick William Hegel was born at Stuttgart on August 27, 1770. When he was eighteen he went to Tübingen, and there studied theology and metaphysics. There also he met his illustrious contemporary Schelling. In a very short time Hegel had to begin private tutorship in order to earn his bread, but the death of his father, leaving him a small sum, enabled him to move to Jena and begin writing.

Everything that partook of the nature of mere material science was abhorrent to Hegel. Every form of empiricism or reliance upon experience was beneath the level of philosophy in his eyes. He never concealed his scorn for the monstrous fashion in which the English were then wont to call a microscope a "philosophical instrument." Thus we find him first tilting against Newton for his astronomical views. The philosophy of Nature, which Hegel's friend Schelling had evolved from his inner consciousness, would not admit of the Newtonian system, and therefore the Newtonian system had to go. Here, at the very first, we see the weak side of Hegel's thought—his contempt for facts, for the fruits of experience, for the method of induction which Bacon had praised, and which all great men of science have practised. Hegel's mind was fundamentally antipathetic to all such methods, and he had self-confidence enough to attack their results, without qualifications for so doing.

Hegel now joined with his friend Schelling in editing the "Critical Journal of Philosophy," and in the same years he met Goethe and Schiller. The great poet saw the quality of his young friend, who was no laggard in his own appreciation of other than scientific genius. In the words of George Henry Lewes, "many a gleam of lustre is shed over pages of the philosopher by his frequent quotation of the poet."

Hegel was now teaching in the University of Jena, and he set himself the task of systematising and improving upon the views of his friend Schelling, with whom he ultimately differed, to his own great distress. In 1807 he finished his "Phenomenology of the Spirit," while the battle of Jena was proceeding. The university was broken up by Napoleon's victory, and Hegel went to edit a newspaper at Bamberg. Later he became professor at Heidelberg, and finally at Berlin.

His principal work, of which the first volume appeared in 1812, is called "Logic,"

but it deals with much more than what we now call logic. It is, in fact, a system of metaphysics, in which a philosophy, an ultimate statement of the nature of things, is evolved by the thinker through the application of logical processes. In many ways, however, the reader of today will gain less from this formidable and wordy work than from some of the later courses of lectures delivered at Berlin, especially from those entitled "The Philosophy of History," printed from students' notes.

Hegel's name stands as that of one of the greatest of the idealists. Intelligence, mind, or spirit is for him the one reality. The material world, with which the "natural philosophy" he so utterly despised concerns itself, is merely an apparatus by and in which spirit manifests itself. It is of no importance in itself, and beneath our dignity to consider. It is the object of thought, and could not exist apart from thought. It is therefore a part or creation of thought. Thus subject and object are one; Mind and Matter are really one. According to Hegel, "the real is rational, and the rational is real." Therefore, if the philosopher can satisfy himself of the rationality of any assertion, that is a true assertion beyond question. Thus, the thought of *nothing* is rational; and therefore nothing, or non-existence, exists. In short, "being and not-being are the same." We may sympathise with the critics who marvel that twenty serious volumes should be based upon "absurdity as a fundamental method."

The vogue of Hegelianism has passed, and we need say no more of it. But this man was a great thinker, none the less. As a student of the history of man and knowledge, Hegel was a master-thinker. Perhaps owing in part to the influence of Goethe, he was an evolutionist, and read history from that point of view. Contrary, however, to those much more numerous evolutionists who propose to explain away the mind of man, and the wonders of life, by reference to the simpler and humbler forms from which they are descended, Hegel declared that man gives us the real key to the animal, and that all organic forms display and reveal what is real, though unseen, in the inorganic world. This reading of evolution is as valuable for us today as it was a century ago.

We owe to Hegel the celebrated saying that the real tragedies of history are the conflicts not between right and wrong, but between right and right. His works have been frequently translated, and perhaps the most distinguished of their contemporary students in this country are Lord Chancellor Haldane and his sister.

Though we reject much of Hegelianism as a sterile system of words, we owe much to the exalted and profound genius of this thinker in many directions. He died in Berlin, of cholera, on November 14, 1831.

HERACLITUS

The First Evolutionist

Heraclitus was born at Ephesus, in Asia Minor, about the year 535 B.C., and lived there throughout his life, of which little is known. He is said to have died at the age of sixty, after a life distinguished, on its external side, by contempt of show

GEORGE HEGEL

and power and fame. He declined the supreme magistracy of Ephesus, on the ground that its citizens were too corrupt. His view of men was so gloomy that, in contrast to Democritus, the "laughing philosopher," Heraclitus was called the "weeping philosopher." He is said to have left Ephesus and lived in the mountains on herbs and roots. When invited to the Court of Darius, he replied as follows:

"Heraclitus of Ephesus to the King Darius, son of Hystaspes, health!

"All men depart from the paths of truth and justice. They have no attachment of any kind but avarice; they only aspire to a vain glory with the obstinacy of folly. As for me, I know not malice; I am

the envy of no one. I utterly despise the vanity of Courts, and never will place my foot on Persian ground. Content with little, I live as I please."

From these and other stories, as to the authenticity of which no one can say, we may argue that Heraclitus was a gloomy ascetic. His writings, unfortunately, have only descended to us in the fragments of his book "On Nature," and we can understand from them why it was that he gained the epithet of the "dark," or the "obscure." Nevertheless, we know enough of the thought of this strange man to assign to him a definite place in philosophy.

We must call him the first evolutionist. He enunciated, as the principle of the universe, "becoming," and, together with this leading idea, he upheld the great principle of continuity, the law of eternal consequences, which is implicit in all modern thought. Everything to him is in a state of eternal flux; "all things flow," as he said, and nothing remains. This doctrine that all things are on an ordered journey is what we call evolution today, and Heraclitus is its first enunciator.

Like all the real makers of thought, Heraclitus has suffered greatly from the misrepresentation of his critics. Even Plato, whose mind was of a very different cast, systematically emphasised those supposed Heraclitean doctrines which least truly represented him; and the great thinker of Ephesus suffers still. Yet we may well marvel when we read the fragments of his work that remain. He had, in part, that idea of rhythm which we find in Herbert Spencer, the modern philosopher of evolution. Fire he conceived to be the principle of all things; and as everything came from fire, so to fire must all things return. It is surprising to note how near this idea of Heraclitus comes to our modern notions of the origin of nebulæ and their history, ending with their rhythmic re-creation by means of fire again. Doubtless what Heraclitus meant was to assert his doctrine of universal flux, as seen in the activity of fire. As he says, "The universe was made neither by the gods nor men; it was, and is, and ever shall be, an ever-living fire in due measure self-enkindled, and in due measure self-extinguished."

He uses other more or less metaphorical expressions for his idea of the universe as a universal becoming. Thus he says, "No one has ever been twice in the same stream, for different waters are constantly flowing down; it dissipates its waters and gathers them again, it approaches and it recedes, it overflows and fails." The stream thus typifies the universe at large, for, as he says, "All is in motion; there is no rest or quietude." The familiar saying that "To live is to change" is thus only a particular case of the doctrine of Heraclitus.

He was a thinker in the realm of morals and conduct also. "Man's character is his fate," he said. "The law of things," he says also, "is a law of reason universal, but most men live as though they had a wisdom of their own." Here we have the sublime conception of morality as no mere conformity to law or custom, but as something grounded in the harmony and law which the thinker sees in Nature. The laws of morality are not local and transient, or the arbitrary pronouncements of some deity. They are part of the laws of Nature, and the philosopher must seek to deduce his moral system accordingly. This is clearly an evolutionary conception, and exactly corresponds to the attempt of Herbert Spencer to write a system of philosophy as a foundation for ethics.

It is impossible to appreciate the real originality, profundity, and courage of Heraclitus unless we try to remember the theological systems in the midst of which he lived and thought. Today we "think in evolution," and find it hard to understand how anyone could think otherwise. The idea of the "laws of Nature" is familiar to us, and we do not attribute the phenomena of the world to the caprices of the gods; but to teach the contrary to superstition, as Heraclitus taught in his day, was one of the greatest achievements of human mind.

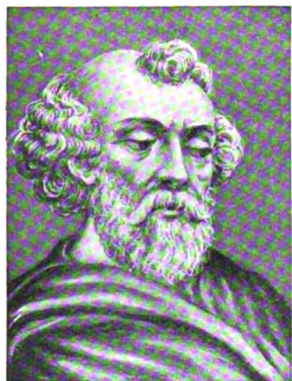
THOMAS HOBBES

Defender of Autocratic Sovereignty

Thomas Hobbes, the defender of sovereign power vested in kingship or other supreme form of government, lived as comfortable a life as any man ever can have lived. His joy was found in his own thoughts, and he had ninety-two years of luxurious quietude in which to think. It is true his life was coincident with all the turmoils of civil war, but they affected him little, though, as a timid man, he contrived to get some fear out of them.

He was born at Malmesbury on April 5, 1588, the son of a clergyman. By the time he was twenty he had taken his degree at Oxford, and was appointed tutor to the son of a nobleman who afterwards became the Duke of Devonshire. Later, he was a tutor to other sons of the house of Cavendish; and

practically the whole of his life—from twenty to ninety-two, when he was not going abroad with young men he was tutoring, or fleeing abroad in fear that he would be taken to task for his writing—was spent as an honoured retainer or friend of the Devonshires of three generations. He lived chiefly at Chatsworth and Hardwick, and died at Hardwick from the effects of a journey thither from Chatsworth.

Hobbes's consistent life as a scholar and quiet thinker was varied by friendships with the notable men of his long extended day. He was the friend of Bacon and Ben Jonson, of Galileo and Descartes. He included a king—Charles the Second — among the young men whom he tutored. Charles, who once cast him off because he had not defended the Divine right of kings, gave him at last a pension of a hundred a year, partly because he admired his caustic wit.

HERACLITUS

To understand Thomas Hobbes and the book into which he put his philosophy of government—" The Leviathan; or, the Matter, Form, and Power of a Commonwealth, Ecclesiastical and Civil"—it is necessary to remember that he lived through long periods when government was very unsettled, when something like anarchy reigned, and the state of public affairs was desperate as seen by a timid philosophical recluse. And so he set himself to consider what were the best conditions of stable government, wherein everyone could have comparative rest. And the theory he evolved was that such a state would most readily be found in a land ruled by Royal authority absolutely, and entirely free from popular control. His distrust of democracy was deep-rooted. One of his earliest literary labours was the translation of Thucydides, because he is the ancient historian who aims most distinctly at an exposure of certain evils of old-world democracy.

The " Leviathan " of Hobbes is the State; and he argues that naturally men live in strife, every man against every other man, unless there is a power to keep them all in awe. The need for such a power is so obvious that men agree to surrender their individual rights to the State, which thus exercises a sovereignty, irresponsible in its absolutism. Only thus can security be ensured. The infirmities of a commonwealth arise when the sovereign has not assumed sufficient power; and the sovereign's first duty is to surrender none of his powers. The sovereignty may be in one man, or in a limited assembly, or in an assembly of all—that is, a monarchy, or an aristocracy, or a democracy, but in any case its power must be absolute and all-inclusive. Arguing on these lines, Hobbes placed the Church, as completely as the individual, under this supreme authority, whether king or democracy.

Naturally such an extreme position created an infinity of controversy. The Church denounced it, and regarded Hobbes as an open enemy. All the defenders of popular liberties were outraged, and for many years liberty found champions who distinguished themselves by showing the unsoundness of the political philosophy which Hobbes declared should be widely taught as embodying the very rudiments of good government. Though he was a shrewd thinker, Hobbes's theories count now for very little; they have become entirely out-dated, but they have proved extremely useful in concentrating the opposing arguments. The existence of a Hobbes led to the existence of a Locke, and Hobbes's value lies in the disproofs of his case which he forced men to undertake in self-defence.

THOMAS HOBBES

DAVID HUME

A Sceptic who Reasoned Reason Away

David Hume, a miscellaneous philosopher of sceptical tone, was born in Edinburgh on April 26, 1711, educated at the university, and lived in the city a considerable part of his life. He was a long while settling down, as he rejected first the law and then trade as a calling, following the true instinct that his business was with books. For three years, gaining a linguistic knowledge that afterwards stood him in good

stead, he lived in France, and there wrote his "Treatise on Human Nature," which contains the freshest exposition of his views. He returned from abroad in 1737, and published his book in 1739, but it attracted little attention. "Essays, Moral, Political, and Religious," followed in 1742. They had been written at his brother's home in Berwickshire.

So far, Hume had failed to find a way of earning a living, and for a year he accepted a post as companion of an English nobleman of defective intellect. Between 1746 and 1749 he served as secretary to General St. Clair, on both military and diplomatic services, and while thus abroad published his "Inquiry Concerning Human Understanding"—a recast of part of his first book. He now returned to Scotland, and published his "Political Discourses" in 1752, a book of considerable note and popularity, on which Adam Smith, later, based his "Wealth of Nations." Hume also in that year published in London an "Inquiry Concerning the Principles of Morals," another re-presentation of part of his first book.

He was now becoming well known as a thinker and *littérateur*, but he failed to secure appointment to the Chair of Moral Philosophy in Edinburgh, and the Chair of Logic in Glasgow. He was, however, made Librarian to the Faculty of Advocates in Edinburgh, and so attained quietude and a command of books that suggested historical work. So he now, in 1754, began his "History of England," with the reigns of James I. and Charles I. continuing it later, forward, and then backward, till, by 1762, it covered from the Conquest to the Revolution of 1688. At the same time he wrote his "Natural History of Religion."

In 1763 Hume returned to public work as secretary to Lord Hertford's embassy to Paris, and for a time remained as Chargé d'Affaires. In France he was a great social success, and on his return brought Rousseau over with him, and George III.—a great admirer of Hume's one-sided "History"—gave the visitor a pension. Hume, in 1766, became Under-Secretary of State for the Home Department, till his retirement to Edinburgh in 1769, on a pension of a thousand a year. He declares, in the brief autobiography which was published the year after his death, that these were the happiest years of his life. He died at Edinburgh on August 25, 1776.

Hume was personally such an agreeable man that he recommended himself even to people who were horrified by his ideas. He described himself as a man of mild disposition, an open, social, cheerful humour, little susceptible of enmity, and of great moderation in his passions; and he declared that though he had exposed himself to the rage of both civil and religious faction, he had no reason to complain of calumny. Yet, for two generations, he stood, with Voltaire, as the twin infidels of the world. His whole tone of mind was critical and destructive. His influence was always negative, and that so powerfully that it forced others to think in counter-action. It is through his studies in philosophy and economics that he lives, and not as a writer of history. Indeed, as a historian he worked on second-hand materials, with inaccuracy and manifest prejudice, but he was the first writer in English who presented history with such grace and finish that its perusal became easy. Dr. Johnson declared that Hume's style was not English at all, but French, and that he only wrote in imitation of Voltaire, but Johnson admitted later that he had never read Hume's "History." Anyway, whatever criticism may hold good against it, it will not be a criticism of style. Hume wrote to please, with love of literary fame as his ruling passion.

The weakness of Hume is that he had no belief to uphold, but revelled in the ingenuity with which he undermined the beliefs of others. Berkeley had argued away the substantiality of matter; and Hume, following out a similar process, contended that no proof could be given of the existence of mind. Our experience, he suggested, is based only on custom, which is the great guide of human life. We form an imaginary entity which we call the soul, but which is only a combination of swiftly succeeding ideas. Mind is nothing but a mere inference. Having thus argumentatively destroyed the mind, and made all philosophies vain, Hume asks whether he believes that the mind has disappeared; and he replies that of course he does not. We continue to think and reason, because the faculty has been antecedently implanted in the mind, though we cannot defend reason by reason. It is philosophising that is vain; we cannot pretend to discuss the nature of essences and causes, but the primary instincts remain, though they may be contradicted by reason. Hume, in short, was a sceptic as regards philosophy, a rejecter of metaphysics as a science.

He was also a sceptic as regards religion—a point that troubled the world much more

than his attitude towards philosophy. His attitude was wholly critical, whether the subject were miracles, revelation, or the immortality of the soul. But his iconoclastic spirit was only active in the region of abstract beliefs; when practical questions of government, involving human liberty, were under consideration, his spirit of doubting inquiry became inactive, or was only exercised against public rights, or the generous enthusiasms that have swept mankind along the pathway of progress; and he was ready to defend tyranny and absolutism of the worst kind. In thought an Anarchist, he was in practical life the Toriest of Tories, though only, as Johnson said, a Tory by chance. The influence of

DAVID HUME

David Hume on the world's thought was like that of Thomas Hobbes, inasmuch as it formed no belief, but set men thinking their way towards the beliefs of which Hume was constitutionally incapable.

WILLIAM JAMES

The Inspiring Psychologist of the Emotions

William James was born in New York in 1842, his father, the Rev. Henry James, being an original and remarkable writer, and his brother, Henry James, being the well-known novelist. He was educated at Harvard Medical School, and took his Doctorate in Medicine there. From 1872 to 1878 he taught comparative anatomy and physiology at Harvard, and then passed on to psychology and philosopny, occupying the Chair of Philosophy at that famous university. He received many academic honours at home and abroad, and gave the Gifford Lectures in Edinburgh in 1901-2, these forming the basis of one of his most interesting books.

Professor James was one of the most arresting, lucid, and suggestive writers on psychology in any age, and he has had an immense influence upon contemporary thought. His earliest and most important work is his great "Principles of Psychology," which was published in 1890, and has been one of the classics on the subject ever since. The "Text-Book of Psychology," published two years later, is an abridgment, and has many advantages for all but the professional student. In 1895 there followed the celebrated essay "The Will to Believe," and the "Talks to Teachers on Psychology," a book which has delighted and guided thousands of teachers all over the world, came in 1899. "The Varieties of Religious Experience" contained the Gifford Lectures, and made a great impression. Lastly, among the more important of James's writings may be mentioned his volume on "Pragmatism, a New Name for Some Old Ways of Thinking," published in 1907.

The last twenty years or so of James's life thus produced a large quantity of writing, in part upon pure psychology, but chiefly upon the borderland between psychology and philosophy. A student so sincere and lovable, humorous, lucid, open-minded, could never fail of readers, and his services to the higher kinds of thought in our time are transcendent. He was a critical and generous reader, an amateur of ideas in the best sense, prepared to see some grain of truth in many various doctrines; and his alert and vital mind set in motion the activities of many younger students who are making the progress of psychology at the present day.

He was deeply interested in psychical research, and was associated with the American Society devoted to that subject. In this respect he showed his open-mindedness, and contrasted notably with most of his colleagues in academic chairs of philosophy or psychology. Perhaps his last, and not one of his least, services to his age was his recognition of the value of Professor Bergson's work, and the part which he played in introducing the younger thinker to a wide audience in the English-speaking world. This was characteristic of James who had no jealousy in his composition.

His mind was so prolific in ideas, in suggesting possibilities, in acute criticism, that it is not easy to do justice to his actual contributions to thought. His careful and complete biological and medical training was of great value, and was doubtless responsible for the theory of the emotions which is specially associated with his name and with that of Professor Lange, who enunciated it independently. The James-Lange theory is that what we call an emotion is merely an organised presentation in consciousness of the various sensations aroused in the body by reflex mechanisms. Thus, when we see danger, we fly; and the flight, which involves violent action of heart and lungs, arouses sensations which we sum up as the emotion of fear. Hence, we do not run because we are frightened, but are frightened because we run. But it is best to quote his own words:

" My theory is that the bodily changes follow directly the perception of the exciting fact, and that our feeling of the same changes as they occur *is* the emotion. Common sense says, we lose our fortune, are sorry and weep; we meet a bear, are frightened and run; we are insulted by a rival, are angry and strike. The hypothesis here to be defended says that this order of sequence is incorrect; that the one mental state is not immediately induced by the other; that the bodily manifestations must first be interposed between, and that the more rational statement is that we feel sorry because we cry, angry because we strike, afraid because we tremble; and not that we cry, strike, or tremble because we are sorry, angry, or fearful, as the case may be. Without the bodily states following on the perception, the latter would be purely cognitive in form, pale, colourless, destitute of emotional warmth. We might then see the bear and judge it best to run, receive the insult and deem it right to strike, but we should not actually *feel* afraid or angry."

This is the most discussed of psychological theories in our time. In the last few years it has been supplemented and superseded by the important observations of Dr. McDougall of Oxford, but we are greatly indebted to James for it nevertheless. We owe much to him, also, for his study of conduct in not only its psychological but also its moral relations. He saw how difficult is the " free-will " controversy, and did not pretend to solve it. But he saw also what he called the " ethical importance of the phenomenon of effort." He pointed out that we largely measure our own worth and status in the world by our capacity for effort.

It is in this that a man " makes himself one of the masters and the lords of life. He must be counted with henceforth; he forms a part of human destiny. . . Thus not only our morality but our religion, so far as the latter is deliberate, depend on the effort which we can make. *Will you or won't you have it so?* is the most probing question we are ever asked; we are asked it every hour of the day, and about the largest as well as the smallest, the theoretical as well as the most practical things. We answer by *consents or non-consents*, and not by words. What wonder that these dumb responses should seem our deepest organs of communication with the nature of things! What wonder if the effort demanded by them be the measure of our worth as men! What wonder if the amount we accord of it were the one strictly underived and original contribution which we make to the world! "

In his "Varieties of Religious Experience," James made a beginning with the scientific and inductive study of a great subject. Individuals vary, and every individual is a scientific document. These human documents must be read if we are to have what science requires—a natural history of religion. Professor James set himself to this task. Undoubtedly his work is open to the obvious criticism that it seems to deal largely with the not merely abnormal but plainly morbid. The critic may ask what light upon religion is thrown by many of these records—though they may throw any amount of light upon insanity. Similar criticism would, however, deprive us of the right to value many of the most precious manifestations of the religious spirit in the past. We may point to the hysterical phenomena displayed by Santa Theresa, and thereupon discount everything she wrote, but that would clearly be folly. We shall do better, in the opinion of James, if we make no attempt to prejudge the value of the phenomena before we have recorded them. As to the value of James's book there can be no doubt. In some important respects it led the way to Dr. Stanley Hall's study of Adolescence, notably as regards the phenomena of " conversion," which are closely associated with early adolescence as a rule. This is a subject the treatment of which in the strictly scientific spirit might readily give offence, but there is no offence in the pages of Professor James.

Near the end of his life he became much interested in "Pragmatism, a new name for some old ways of thinking." The chief argument of this philosophy is that the test of truth is pragmatic or practical. What is true is what works. The reader will readily see that delusion may work, in many a case, and thus be ranked pragmatically true for the believer. But for the discussion of this very attractive subject he must refer to the pages of James or of his followers, such as Dr. Schiller.

William James died on August 26, 1910.

IMMANUEL KANT

The Philosopher who Looked Within

Immanuel Kant was born on April 22, 1724, at Königsberg, where he spent the whole of his long life, never travelling more than twenty or thirty miles beyond its walls. He was of Scottish descent on his father's side, the name being originally spelt Cant. His external life, as we may surmise, was extremely uneventful. "He lived and died a type of the German professor; he rose, smoked, took his coffee, wrote, lectured, took his daily walk—always at precisely the same hour. The cathedral clock, it was said, was not more punctual in its movements than Immanuel Kant."

His first interests lay in mathematics and physical science. He read Lucretius, and from a passage in his famous poem he formulated a theory of the origin of the solar system by the contraction of a nebula. In after years this became the famous "nebular theory" of Laplace, but the first statement of it stands to the credit of the juvenile Kant. He also predicted the existence of the planet Uranus, a prediction which Herschel duly acknowledged when his telescope revealed the new planet.

Then came the philosophical works upon which Kant's fame rests. The earliest and greatest of these is the "Critique of Pure Reason," which was published in 1781, and which, he tells us, was the product of twelve years' meditation. It is a most difficult and unattractive book to read, loaded with terminology, and almost without form, though anything but void. For some time it attracted little attention, but at length it became famous, and its author's disciples began to fill all the philosophical Chairs in Germany. Seven years later came the "Critique of Practical Reason," the second most important of Kant's works. He wrote many other books, of the translations and criticisms of which there is no end, for Kant, by general consent, is accepted as the leading figure in modern philosophy.

That is easily said, but it is not so easy to state, in a few words, the teaching of this thinker. He has often been called "transcendental," and this term has led many to regard him as a mystic, and one who soared altogether above the realm of the intelligible. The proper name, however, for Kantism is the "critical philosophy." This was the name he used himself, and it indicates his essential task, which was the criticism of man's experience and knowledge. How much are they worth, what is their real validity, may we trust to them, or must we abandon ourselves to scepticism?

Kant's answer was that our knowledge is trustworthy in so far as it is based upon laws of the mind, which are true and real; but that our knowledge is limited in so far as it can only be a knowledge of phenomena or appearance, while *noumena*, things in themselves, must for ever escape us. He is thus not a sceptic, who denies the possibility of knowledge, nor a "common-sense" realist, who says that things are what they seem, and there's an end on't. He occupies a middle and reconciling position, also, between the idealists, who deny the existence of the external world, and the materialists, who regard the external world as reality. He denies the existence neither of spirit nor of the physical universe. Nay, more, he argues that our knowledge of the physical universe is only phenomenal; and that if we could know the reality of which physical things are the phenomena, we should find that reality to be spiritual too, like the knowing mind itself. This is perhaps the greatest idea in all the Kantian philosophy.

Time and space, for Kant, were forms of the mind, under and in which it framed and perceived and arranged external things. Hence the mind arranges things in a number of categories, as he called them, such as unity, multiplicity, possibility, necessity, and several more. By further argument, he shows, the mind arrives at three transcendently important ideas—the soul, the world, and God. So far as the "pure reason" is concerned, these are only ideas, by no means demonstrated.

Here, however, the "practical reason," as Kant called it, enters upon the scene. In our conscience we find, said Kant, a "categorical imperative," which we are bound to obey. This furnishes the practical guide of life. It is something older, deeper, more valid than anything derived from experience. It

demands certain things of us; and when we try to comply with its demands we find that the ideas of God and of the immortal soul, which were no more than ideas for the pure reason, now become necessary truths for the practical reason. They are thus, and thus alone, established. The moral law within, given us by Conscience, and demanding moral perfection, cannot be satisfied unless the soul be immortal; and the moral demand for universal goodness and happiness cannot be met unless a Supreme Intelligence rules the world.

Such are Immanuel Kant's arguments. We observe that they are derived from introspection. The philosopher has no need to travel, to note the varieties of human experience. He looks within, observes the processes and results of his own mind alone, and reaches his conclusions accordingly. Thus, judging by his own noble personality, Kant concluded that the two most admirable objects of human contemplation were the starry skies above, and the moral law within. Kant died on February 12, 1804, having nearly completed his eightieth year.

RALPH NORMAN ANGELL LANE
A Forerunner of the Age of Peace

Ralph Norman Angell Lane, the brilliant thinker who, in our own time, is changing the world's thoughts about war, was born in England in 1874, educated at the Lycée de St. Omer, in France, and began life on his own account in the Western States of America. He was still a youth when he crossed the Atlantic in search of adventure. He has seen life in the wild territories of the Western States, he has held a high post close to the heart of things in Europe, and life has passed before his eyes like a panorama of romance. Yet he can truly say, as he looks out upon the world, with the age of forty still on his horizon, that of all the romances he has known the romance of Norman Angell is the strangest and most unexpected.

It was one morning in 1910 that the writer received from Paris a little red book, with a note from Mr. Lane hoping that he would find it interesting. It was a little volume called "Europe's Optical Illusion," and the writer put it aside and forgot it for weeks. The editors of all the newspapers in England did the same, and the author, hard at work in his newspaper office in Paris, may have been forgiven if he began to regret that he had published the book at his own expense. For two months nobody seemed to notice this little red book by Norman Angell, and only the friends who remembered his rarely used middle names connected the book with the man who sat at a desk day by day directing the fortunes of an English newspaper in Paris. His genius showed itself there in racing all other English papers to all parts of Europe, and the writer remembers still the sensation with which he received, 600 miles up the Nile, an English paper from Paris only four days old. The clever brain of Norman Angell had made that possible; even thus, in his own quiet way, he was hastening the spread of knowledge over the earth.

But it must have seemed to him at that time as if he were doomed to remain at his desk controlling the distribution of a newspaper, for his little book, the second child of his brain, seemed to have fallen, like the first, upon a dead world. Then an extraordinary thing occurred. The book the newspapers had overlooked, that members of Parliament had not yet seen, that booksellers kept at the back of their shelves, was discovered by the King of England, was mentioned in a speech by Sir Edward Grey, was introduced to the German Ambassador by Lord Haldane, was read by the King of Italy, was bought in large numbers by a great friend of King Edward, and distributed among the governing men of Europe. Norman Angell woke up to find himself famous. Letters poured in upon him from Parliaments and palaces, and from that day to this the stream of his correspondence has never ceased, but has grown so that secretaries can hardly keep pace with it; and no secretary can understand all the languages in which these letters are written. "Europe's Optical Illusion" has been re-written and enlarged, and has now appeared in more than twenty languages as "The Great Illusion." It is not an exaggeration to say that it is entitled to be compared in its effect upon thought with Darwin's "Origin of Species."

No book that has ever been written on war is quite like this book. Norman Angell's is the most powerful pen that has yet set out to fight the sword; "The Great Illusion" is the deadliest gun that an author has ever fired at war. Perhaps the history of the book may throw some light upon the nature of it.

Mr. Lane set out for the Western States of America, as we have said, in search of adventure. And he found it. He became secretary to a candidate for the American Legislature at about the time when President Cleveland was exciting the United

States about Venezuela and the Monroe doctrine. The farmers of the West, encouraged by senators and professors and merchants, were buying up firearms to march against England. Great Britain must be destroyed, and these farmers would destroy her. Many thought this absurd; only Ralph Norman Angell Lane seems to have realised that for these farmers to seek to destroy their own market because England proposed to take over a few miles of swamp, and for sixty or seventy million people to take a similar view of the situation, implied that the whole political thought of these people must be defective at its very roots, and spring from some profound illusion. Mr. Lane's candidate lost or won, and Mr. Lane came to Paris. Here the excitement was the Dreyfus case, and the Frenchmen believed—as Mr. Lane himself heard an ex-Cabinet Minister say—that Europe was leagued to annihilate France, that England was at the head of the conspiracy, that millions of money were being poured into France to set Dreyfus free and so strike a blow at the State. *Only Ralph Norman Angell Lane seems to have realised that, for millions of people to believe this, their thought must have started wrong at the beginning, that France was endangering her markets for a great illusion.* Mr. Lane sat down and wrote a book pointing out the great illusion, and basing his case on moral grounds. The book was a failure. A few remainder copies are all that can be had of "Patriotism Under Three Flags." The world refused to hear Norman Angell as a preacher.

But to him the great illusion was a great reality. For ten years he gathered up his facts, pulled together the threads of his argument, talked the matter over with great financiers, and at last, in 1910, the still, small voice of the little red book was heard in the wilderness of Europe. The world that turned a deaf ear to the moral appeal was compelled at last to listen to the incisive logic of economic fact.

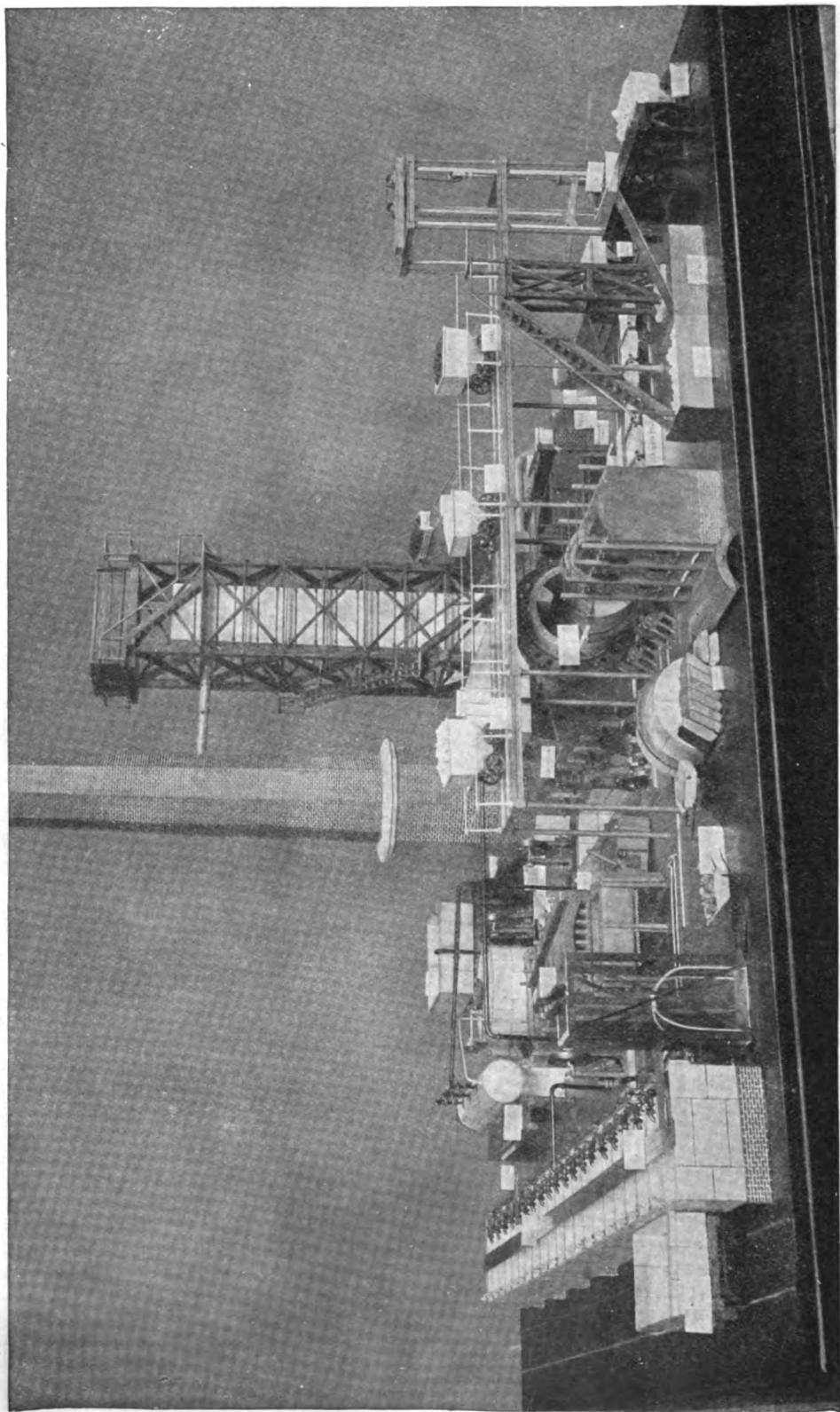
The philosophy of "The Great Illusion" is, in brief, that, though war is still and will for ever be possible, if men remain foolish enough to wage it, the present generation has seen the weaving of a delicate fabric which has so spread over the boundaries of all nations, touching the nations in vital places, and so sensitive that the tearing of one part affects the whole, and war between civilised peoples can never again bring advantage to the victor. This fabric is our economic system, or international finance, the network of nerves which covers the earth so that the looting of the Bank of England by a German army must break the Bank of Germany too, and cause collapse in all the capitals of Europe. War, therefore, cannot pay, since the victor is unable to use force against the vanquished for economic ends. So interdependent are we now that the victor must leave the vanquished alone; and he need not conquer him in order to do that. But the illusion that a foreign army can come to London and carry off the gold of the Bank of England is only one part of the Great Illusion in the minds of the war-makers; another

RALPH NORMAN ANGELL LANE

is that a foreign army can come to England and conquer the people, change their nationality, and make them Germans.

That again, says Norman Angell, is a superstition. The British Empire holds together as a series of free States; not even England could compel a single one of these States to change their language or their staple industry, or to transfer their energies or their revenues to other purposes.

The book in which these theories are set forth and amplified is a brilliant piece of thinking. It has never been answered. It is winning over merchants, statesmen, financiers, and professors; it is creating new groups of thinkers in Europe and America; it is making its way in China and India and Japan. It has made Norman Angell a national figure whose time is not his own, but whose brilliant mind is destined to carve out for him a monument which will not crumble into dust.

A PROOF OF THE COMPLEXITY OF THE PROCESS BY WHICH CHEMICALS ARE CHEAPENED

A MODEL OF THE PLANT FOR THE MANUFACTURE OF SODA BY THE LEBLANC PROCESS, DISCOVERED IN 1790

INVENTORS

JAMES HARGREAVES

The Man who Made Lancashire

James Hargreaves, inventor of the spinning-jenny, was born at or near Blackburn about 1745. Absolutely without education, Hargreaves proved himself one of those rare mechanical geniuses by whom Lancashire had the vast cotton industry thrust upon her. The potentialities of the industry were there, but the ingenious contrivances of Kay, Arkwright, Cartwright, Crompton, and Hargreaves had, with peril to personal fortune, surreptitiously to be introduced. And the manufacturers, after the fury of their employees had had full play, stole the inventions and left their creators for the most part to die in comparative poverty. Hargreaves, contrary to common report, did not die in indigence, but his family, soon after his death, were in the depths of despair, and this may account for two of them appearing in court in the endeavour to rob Arkwright of the credit of two inventions incontestably the creation of his own fertile brain.

Hargreaves was engaged for many years in the cotton mill of Sir Robert Peel's grandfather at Blackburn. There he was employed to effect improvements in the carding-machines in order to displace the hand-cards then in use for clearing and straightening the cotton fibres preparatory to their being spun. Arkwright's machine had yet to be evolved, and wefts were far to seek. The story still preserved in Lancashire annals is that Hargreaves was waiting for the weft that his wife was to produce when he accidentally knocked over her spinning-frame. It was a primitive, one-thread wheel; and, as it lay upon its side, the wheel and spindle, thus thrown from a horizontal into an upright position, continued to revolve. In a flash Hargreaves saw, as he watched the confusion of thread, that by widening the wheel and placing a number of upright spindles side by side he might be able to spin several threads at once. Very secretly he fashioned his jenny.

It is interesting to note that two of the most important gifts to Lancashire's staple industry, the spinning-jenny and the mule, were the work of men who intended their inventions solely for their personal use. Hargreaves desired a jenny which should spin several threads at once instead of one, so enabling him comfortably to earn more money for his numerous family. Crompton had a bad edition of one of the earliest Hargreaves jennies, and gave five of the best years of his life to bettering it, to the intent that he, Samuel Crompton, and not the industry as a whole, might profit. The efforts of talented men and boys to save themselves labour in this way have had great results for the world. Idle Humphrey Potter, to avoid the fatigue of earning his bread in the appointed way—by opening and shutting the cocks admitting steam to the cylinder of the steam-engine—first fashioned a system of springs and levers which enabled him to cause the engine automatically to govern itself. It gave him time to loaf, but it also bestowed a priceless boon upon the makers of steam-engines, for from this lazy young genius's invention proceeded the first engine that worked its own valves. Edison, shirking the trouble of giving a telegraphic signal at stated intervals during the nights of his drudgery as a boy in a railway-station telegraph-office, devised an arrangement making the telegraph automatically communicate the signal he was there to supply. That, again, was the parent of a highly important series of kindred inventions.

Hargreaves had no thought but that of private personal gain, of earning, more

expeditiously and easily, a sufficiency of bread, but in winning success for himself he was unconsciously enriching his native county by millions sterling. The spinning-jenny, primitive as it left his rough, talented hands, worked wonderfully. It is said that he called the machine after his wife, Jenny. Those who wrongfully assert that Thomas Highs, from whom Arkwright was alleged to have borrowed the idea for his water-frame, was the inventor of the jenny urge that the name must have originated with Highs, from the fact that he had a daughter named Jenny, whereas Hargreaves had not. But there can be no doubt as to Hargreaves having originated the machine called by his name. He did not immediately reap from his spinning the profit for which he had hoped, so he quietly made one or two other machines, and sold them to neighbours and friends. That settled his fate, so far as Lancashire was concerned. Those who have read the life-stories of Arkwright and Crompton will be prepared for the sequel.

The neighbours in whom he had not confided were at first alarmed at his producing eight times as much yarn as they could; then they became jealous, and told the story abroad of machinery that he had invented. The mere mention of machinery sufficed to stir the passions of the mob. The machine would dispense with human labour, they said; the country-side would languish and perish of inanition. Blackburn, which was to be "depopulated" by this diabolical contrivance, then boasted a population, be it noted, of five thousand people. Such men as Crompton, Hargreaves, and Arkwright have given it a trade which supports thirty or forty times that number, and the mills are still rising. But the town was to be beggared then, and so were the lesser towns round about.

It was a matter of general concern; the evil spirit of the Hargreaves mechanism must at all costs be exorcised. It was not a case of half measures, but of solemnly furious concerted action. The free and independent cotton operatives from Darwen (the Peaceful Valley!), Mellor, Tockholes, and Oswaldtwistle assembled in Blackburn, there to join the local operatives. In procession they made their way to the cottage of the hapless inventor. He was not at home, so they entered the house, utterly smashed the spinning-jennies, reduced the household furniture to matchwood; marched in serried array to the mill of Robert Peel which had sheltered the industrial serpent, and wrecked that as completely as the cottage. And when Hargreaves fled dismayed to Nottingham, and old Robert Peel and others masters inclining to the heresy of machinery quitted Blackburn, the local operatives felt themselves heroes, saviours of their county, and veritable pivots upon which the prosperity of the kingdom revolved.

Nottingham, which was to afford sanctuary to Arkwright, was hospitable to Hargreaves. He had the fortune to fall in with a certain Thomas James, a Nottingham carpenter, who had a little capital and more imagination, and together the two men put up a small factory, erected a number of spinning-jennies, and prospered. The jenny was patented in 1770, some years after its successful trial at Blackburn. Very soon Lancashire manufacturers pirated the invention, and the instrument which was to wreck the industry of the county gave the trade an enormous impetus. Hargreaves entered actions for infringement of patent-right, but when his lawyer heard how many Blackburn manufacturers had stolen the invention his heart within him fainted; he threw up his brief rather than fight an army! Hargreaves, however, made money, and is said to have been worth some seven thousand pounds at his death. He died at Nottingham on April 22, 1778.

It was the subsequent distress of some of his children which gave rise to the tradition as to his own desperate condition. Theirs was real enough, and an admirer of their talented father sought to raise a subscription for them. But as they never forgive who do the wrong, the Lancashire manufacturers, who were waxing fat upon the fruit of the dead man's genius, were the last willingly to contribute. Lancashire does well by her people today, but there is an account against her and them for the treatment meted out to the pioneers of the industry upon which both have developed that history will never forget.

JOHN HARRISON

The Cleverest English Clockmaker

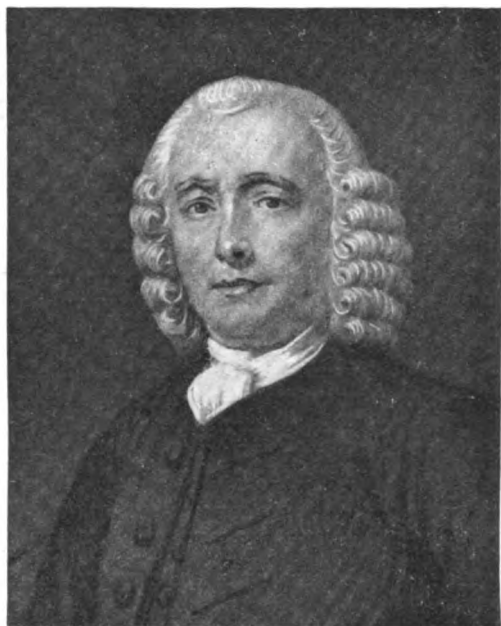
John Harrison was born at Foulby, Yorkshire, on March 24, 1693. The Brindley of horologists was the son of a carpenter in the employ of Sir Rowland Winn. As a child he evinced a great natural aptitude for mechanics, and when still young was taken as his father's assistant in the carpenter's shop. Of school education he had but a minimum; and to the last, though he could plan the most delicate mechanism,

he found it a matter of the greatest difficulty even to express himself in words, to say nothing of the task of putting his thoughts upon paper.

His special forte was clockmaking. From the time that he first saw the "wheels go round," they were, so to say, always revolving in his brain, and his first considerable task was the making of an eight-day clock. Except the escapement and dial, which were of brass, the mechanism consisted entirely, wheels and all, of wood. Those who have anything to do today with the cutting by refined machinery of gear-wheels will understand with what accuracy the village horologist must have worked, and even the man who drives a car whose gears are noisy and ill-married will grasp the significance of the feat. That clock, made by Harrison when he was twenty years of age, is to be seen at the South Kensington Museum, where, after a century and a half of wear, it was still in good working order.

Harrison's next feat was a very important one—the making of the gridiron pendulum. The man whose clock gains or loses with alterations of temperature may take it that John Harrison is not justly represented in the timepiece, for the gridiron pendulum is so composed that a compensatory movement automatically counters the effect of expansion and contraction, so causing the clock to tick at its accustomed pace, whatever the weather. Harrison added the making and repair of clocks and watches to his daily task as carpenter, and did a little land-surveying.

A friendly parson lent him a manuscript essay on natural philosophy by Saunderson, the blind philosopher, and Harrison sat up night after night to copy it, word for word, diagram after diagram. It is noteworthy, by the way, that two of our heroes of science, Dalton and Harrison, should be materially assisted up the ladder of learning by the sightless. In the life of James Hargreaves mention will be found of important inventions evolved with no appreciation of their ultimate importance, but merely to save the labour of their creators. Harrison's career affords another example. He had charge of a turret clock which it was necessary frequently to visit in order to oil the escapement. The villager puzzled over this for some time to invent a device that would save his steps, and give him for other tasks the time consumed in climbing up and down the turret. And to John Harrison's desire to save his heels we owe the recoil escapement—a masterly contrivance for the lessening of friction and saving of lubrication.

Some of Harrison's inventions for the improvement of clocks were not without parallel in his own age, for many well-trained, scientific minds were directed to obtaining instruments for correctly recording divisions of time. It was against these greater luminaries that the humble Harrison had to compete. At this time prizes amounting to £45,000 were going begging, and none of Harrison's illustrious contemporaries had found it practicable to gain them. In spite of all the fine feats achieved by our voyagers, navigation

JOHN HARRISON

was still vastly complicated and dangerous by reason of the absence of anything like a dependable chronometer. It was easy enough to find the latitude, but to find the longitude was quite another story. To determine the longitude we must have *time*—Greenwich time, to show us what o'clock it is in the spot which gives the hour of day to the world, and local time, the time of the locality in which our ship happens to lie. For every degree of longitude east of Greenwich our time will be four minutes fast of Greenwich mean time; for every degree of longitude west of Greenwich local mean time will be four minutes later than Greenwich. These differences become, of course, considerable over a long voyage. Thus, West Australia

is eight hours fast of Greenwich, while America is four hours behind us on her Atlantic coast and eight hours slow on the Pacific Slope. Now, in order to fix the longitude we must have a chronometer which will neither vary nor lie.

Such a thing as a really dependable watch was unknown in Harrison's youth. An Act of Parliament was passed in 1714 offering rewards of £10,000, £15,000, and £20,000 to anyone who could discover a method of determining the longitude at sea severally within sixty, forty, and thirty geographical miles. All means in earth and sky and sea were open to the inventive, but in effect it came to this: "Give us a dependable watch, a watch which will keep time at sea through rough weather and smooth, and here is £45,000 for it." Clerkenwell on the same terms could win the prize every day in our times, but Clerkenwell had not got a Harrison when the money was available.

At that period the conditions were such that the Government was prepared to pay £10,000 to anyone who could enable a navigator to fix his bearings within *sixty* miles. The prize was open to the whole world, but the illiterate Yorkshire carpenter was the man to gain it. He exhibited his first drawings to Halley in 1728; was passed on to George Graham, himself a considerable horologist; was advised to reduce his theories to practice, and for seven years worked at his first chronometer. Tested in one of the Admiralty ships on a voyage to Lisbon and back, it stood the test of rough weather in the Bay of Biscay, and, upon the return journey, achieved a result recorded in the following certificate furnished by the captain: "When we made land, the said land, according to my reckoning (and others') ought to have been the Start; but before we knew what land it was, John Harrison declared to me and the rest of the ship's company that, according to his observations with his machine, it ought to be the Lizard—the which, indeed, it was found to be—his observation showing the ship to be more west than my reckoning, above one degree and twenty-six miles"—that is, nearly ninety miles out of its course in a voyage of about 1400 miles. The first marine chronometer had come into existence.

Our miserly Government behaved with unparalleled shabbiness to Harrison. So far he had conducted all experiments and work at his own cost, and, now that he desired to make a second and better chronometer, and needed money with which to carry out the work, the Commissioners offered £250 down, and £250 when they should be certified that the new chronometer had been placed on board a warship bound to the West Indies. Graham advised that the grant should be at least £1000, but the Commissioners adhered to their offer, and with that Harrison had to be content. He had already far outdistanced all rivals, but he went from timepiece to timepiece, each better than its predecessor, and, by devoting himself entirely to the work, was reduced to debt and poverty, and had repeatedly to apply for assistance. His third timepiece brought him the Copley medal, and congratulations from men of the highest eminence that would have impressed anybody but members of a fatuous Government department.

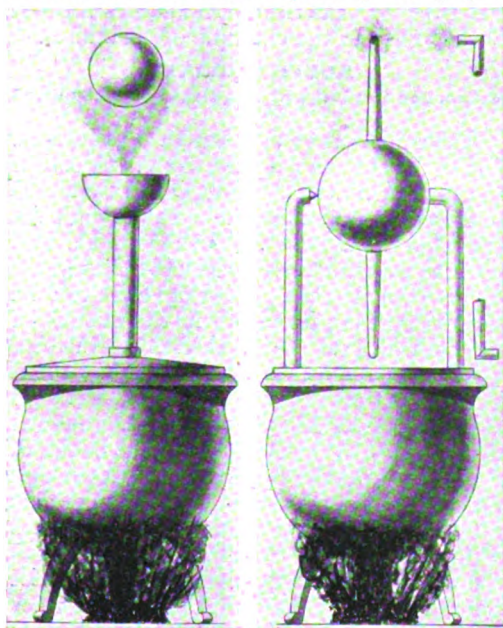
The fourth Harrison chronometer took a fleet out to Jamaica, enabling it to overhaul ships which had started ten days earlier, but which had been astray through having to trust to the log. It brought another ship home with an error of less than two minutes, or about eighteen geographical miles. The Government, though pledged to award the £20,000 prize for determining the longitude within thirty miles, declined to make the award. Trial after trial was made, each better in result than its predecessor, and all well within the conditions, but not until thirty-six years of shameful shilly-shallying did the Government meet its obligation, and award Harrison the prize he had won, a generation before, for determining, for the first time, the longitude at sea. Harrison was eighty when he received the balance of what he had earned when forty-four years of age. He died in London on March 24, 1776.

HERO

An Ancient Applier of Science to Daily Life

Hero, one of the great figures of ancient science, flourished about 100 B.C. He is commonly spoken of as the pupil of Ctesibius, who seems to have been some twenty years the senior of Hero. Both were prominent figures at the wonderful school of Alexandria. The city, founded two centuries earlier by Alexandar the Great, had become not merely the world's commercial emporium, but the repository of all learning and science. In the time of Hero it had a population of 300,000 free citizens, besides a still larger number of slaves. The city and school had attained the climax of their splendour during this period—the lifetime

of Cleopatra, with whom, in 30 B.C., the line of the Ptolemies finally died out. Greece sent her brightest sons to Alexandria; the Romans sent their legions, and made the city their own.

From Alexandria the rest of the world took its scientific teaching. All physiological, astronomical, and geometrical laws issued from the studies of the savants of Alexandria, or from the wise men to whom their learning had reached, and with whom they maintained a correspondence. Geometry originated, Herodotus tells us, from the needs of the people to re-establish the boundaries of property which every inundation of the Nile obliterated. Hero and his master, but more especially the pupil,

HERO'S STEAM EXPERIMENTS

were foremost in settling problems of this character. Hero improved upon all previous instruments by inventing what is known as the dioptra, of which our modern theodolite would seem to be the true descendant. He for the first time placed it in the power of the surveyor correctly to re-establish a boundary of which the plan existed or one or two points were known.

He is best remembered, however, from his investigations into the properties and potentialities of steam. When the Hon. Sir Charles Parsons went to the Patent Office to enter his caveat in respect of his famous steam-turbine, he found nearly a hundred inventions recorded, all carrying some distance along the line by which he had advanced to his goal. He did not find Hero's recorded, but it was the first of all the steam-turbines. It was little better than a scientific toy, and lacked piston and cylinder. The steam, generated in a closed cauldron, was conducted through a tube into a large metal ball, and, escaping by way of a couple of nozzles, in so doing caused the ball to revolve. After Hero's death the idea lay dormant for over two thousand years; it has been revived, or independently thought out, in our own day to revolutionise marine engines.

Another of his inventions was the hot-air engine. A fire upon the altar of a temple heated air contained within a hollow chamber, causing the air to expand and force a column of water into another vessel, and so actuate a pulley by which the doors of the building were opened or closed as required. By means of a double-acting force-pump he made the first fire-engine. His writings deal with the raising of weights, with the projection of missiles, and the use of compressed air and steam as motive-powers. Altogether a very striking figure is Hero of Alexandria, the centre of many legends as to modern inventions anticipated, but demonstrably the creator of remarkable mechanical appliances which show the first application of science to the needs of daily life.

PETER COOPER HEWITT
A Millionaire Devoted to Invention

Peter Cooper Hewitt was born in New York in 1861, the son of a wealthy, successful, and ingenious ironmaster, a politician, and reform mayor of New York. His grandfather is said to have built the first American steam locomotive, and the grandson believes that he himself has certain talent in the same direction, for he has invented a motor-car, or improved, he hopes, upon other makes. But it is as the inventor of the vacuum electric lamp, in which the vapour of mercury takes the place of carbon or other filament, that he gains a place in these pages. The lamp is fully described upon page 2894 of the present work.

Mr. Hewitt's method of reaching that invention was interesting. His grandfather gave him a chest of tools for a toy, and expected him to use them in the right way. He did. He was a mechanician before he was a scholar. Not that his scholastic training was neglected; he was well grounded in electricity, physics, chemistry, and mechanics, first at a day-school, and afterwards at Columbia College. Then he was introduced to a still better school—the

works owned by his father and grandfather. Here he turned his hand to improving the plant for glue-making, in which he effected a revolution during his eight years' association with this aspect of the family business. Later he went right through machine-shop practice, from smithy-work to machine-fitting, and also took a turn at jewellery work, which at any rate served to develop his faculties for exact and careful manipulation on a very small scale.

Having thus tried his strength, he cast about for something on which to exercise it profitably. Seeing that the best electric lamps in existence were wasting in heat about 99 per cent. of the power supplied to them for conversion into light, he began investigations in this direction. His experiments extended over six or seven years, and involved the use of many different media, but he found that all produced too much heat and too little light, until he hit upon mercury. He knew nothing at the time, he says, of the fruitless experiments that had been made by others in the same field, but went to work as upon an entirely new plan. For long he was baffled by the resistance of the mercury in the vacuum tube to an electric current. He made what he estimates to have numbered thousands of trials before hitting upon the right combination. Quite unexpectedly, he was successful, for, after sending a strong current through his tube, he followed up with a weak current, saw a series of flashes, and realised that the mercury vapour was conducting. Repeated trials enabled him to reduce his guess to a certainty. When once the resistance of cold mercury is overcome, a much less powerful current finds a ready passage and produces a brilliant light—the glow of the mercury vapour. It remained for him to fit a coil supplying a powerful initial current, and, the primary resistance of the mercury being overcome, it was necessary only to substitute the weaker current to gain, from the current normally supplied to incandescent lamps, from eight to nine times the volume of light yielded by the filament lamp. How he had to overcome the surprising difficulty arising from the absence of red rays from his light is described on page 2894 of "Popular Science."

His first invention led him to two more. He found that the mercury lamp, when connected with wires conveying an alternating current, possesses the power of converting that alternating current into a direct current. Further research in the same direction led to the invention of the electrical interrupter for use in wireless telegraphy. The mercury opposes a high resistance to the passage of electricity up to a certain potential, when it gives way, and allows a current of low potential to become effective. This property he proposed to apply to wireless telegraphy by using the mercury to break a strong current, such as is used in radial telegraphy, to produce waves of the same length for sending through space.

As a partner in the firm which bears his name, Mr. Hewitt has had time for his experiments only at nights; and his success, achieved without the incentive which may energise the needy man, is pointed to with pride by his countrymen as evidence that the sons of American millionaires are not always false to the example of their sires.

ROBERT HOOKE

A Crooked Genius with the Brain of a Hundred Men

Robert Hooke was born at Freshwater, Isle of Wight, on July 18, 1635, the son of the parish minister. Congenital weakness rendered it impossible to educate him for the Church, as was his father's wish, and until he was thirteen he was left pretty much to his own devices. During this time he showed striking ingenuity in the making of mechanical toys. Left fatherless at thirteen, with only £100 as his portion, the boy spent some little time as pupil to Lely, then passed to Westminster School, where he astounded his mentors by mastering the six books of Euclid in a week, by acquiring Greek and Latin and Oriental languages at an incredible rate, by expounding "thirty different ways of flying," and by teaching himself to play the organ. At eighteen he entered Christ Church College, Oxford, as chorister or servitor, and eventually obtained his M.A. degree. He now became associated with Robert Boyle, as assistant, residing in his house and helping with his experiments. Boyle states that it was Hooke who suggested to him the first improvement on Guericke's air-pump. The new instrument, which he describes in his "Physico-Mechanical Experiments," had two barrels moved by the same pinion-wheel, and thus did twice as much work in the same time as its predecessor. This is believed to have been Hooke's invention.

There is nothing in the idea to surprise, for Hooke became the greatest philosophical mechanic of his remarkable age. There was no aspect of mechanics or of abstract science into which he did not plunge, and none from which he did not emerge with new

inventions, facts, and theories. He anticipated the flying-machine; he was ahead of Newton in divining the true doctrine of universal gravitation, though he was not mathematician enough to demonstrate his theory. He invented the first circular pendulum for watches, produced the parent form of the modern electric clock, manufactured a thermometer; experimented in optics, in surgery, in industry, in architecture, in music; anticipated the steam-engine; improved the telescope, quadrant, and microscope; made important advances in astronomy, and discovered the law of extension and compression of elastic bodies.

Hooke was one of the great figures of the Royal Society in its early days. He was appointed first its Curator of Experiments, and later its secretary. As Professor of Geometry in Gresham College, he was provided with rooms there, and lived at the college until his death, which occurred on March 3, 1703. Hooke's work helped materially to lift science out of the mists of empiricism and quackery. He was not always right in his deductions—infallibility is not the gift of any man—but the blunders he committed were infinitesimal contrasted with the amazing correctness of his innumerable other speculations. He discovered the true properties of heat, the method of the propagation of sound, the use of the pendulum as a means of measuring the force of gravity, caused sounds to travel along a wire long before the telephone was dreamed of, and outlined a system of telegraphy. In fact, it has been well said that there was no important invention by any philosopher of that time which was not, in part at least, anticipated by this extraordinary man. While the Royal Society was amusing itself with such trifles as "the skin of a Moor, tanned, with white hair," Hooke was occupied in matters of which worthy Samuel Pepys gives us some enchanting glimpses. The time was that of the Plague; and while doctors are gravely discussing whether, their patients having fled the stricken city, they might not justly follow suit, Hooke was quietly at work with his thousand occupations. He peeps out from the pages of Pepys like some benevolent magician; and it is worth while to spend a minute or so in his company, and with that of the men with whom he moved.

After a dinner with the "old jokers" at Trinity House, Pepys goes, in February, 1664, to Gresham House, to be admitted a member, and there for the first time meets Hooke—a small, crooked man, "who is the most, and promises the least, of any man in the world that I ever saw." Here from eight till ten he hears their discourses and witnesses their experiments, "which were this day on fire, and how it goes out in a place where the ayre is not free, and sooner out where the ayre is exhausted," and so with them all to a club supper at the Crown Tavern, behind the 'Change. In the following month (March, 1664) our diarist returns to Gresham College, "where Mr. Hooke read a very curious lecture about the late Comet, among other things proving very probably that this is the very same Comet that appeared before in the year 1618, and that in such a time probably it will appear again, which is a very new opinion." Next the philosopher, with an illustrious company, takes him to Greenwich, "to the tryal of some experiments about making of coaches easy," one of which they all "rid" in, and found mighty easy from the fact that "the whole body of the coach lies upon one long spring." They are still experimenting with coaches in the succeeding year, and my Lord Brouncker, with Hooke in attendance, rides in one "where the coachman sits astride upon a pole over the horse, but do not touch the horse, which is a pretty odde thing." This is the first gathering of members at Gresham College since the outbreak of the Plague, and "what, among other fine discourse, pleased me most was Sir G. Ent about Respiration; that it is not to this day known, or concluded on among physicians, nor to be done either, how the action is managed by Nature, or for what use it is."

Ent, be it noted, was President of the College of Physicians at that time. The crooked little man in his company was destined to teach him something as to the manner in which we breathe, and why. From comets and coaches to felt-making. "And here [Gresham College] a good lecture of Mr. Hooke's about the trade of felt-making, very pretty."

Two years later the diarist again meets Hooke, and has from him a discourse about the nature of sounds. "And he did make me understand the nature of musicall sounds made by strings, mighty prettily; and he told me that, having come to a certain number of vibrations proper to make any tone, he is able to tell how many strokes a fly makes with her wings (those flies that hum in their flying) by the note that it answers to in musique during their flying." Samuel indulges in a sceptical chuckle as he jots down his information,

his comment being: "That, I suppose, is a little too much refined; but his discourse in general of sound was mighty fine."

When next they meet, Hooke has been trying experiments in the transfusion of blood. He was ready enough to experiment upon himself, as when—varying labour on the cutting of toothed wheels for watches, and exploring the mysteries of soap-bubbles and earthquakes, and enunciating theories of light and heat, respiration and combustion—he submitted himself to trial in an exhausted receiver. But now he tells Pepys: "The dog which was filled with another dog's blood, at the college the other day, is very well, and likely to be so as ever."

Such were the multifarious activities of this man. But the list is not exhausted. After the Great Fire he designed and exhibited a model for the rebuilding of the ruined capital; and, though it was not adopted, his scheme gained him the appointment of City surveyor. He designed, in this capacity, the new Bethlehem Hospital, Montagu House, the College of Physicians, and other buildings. The money he received for his labours he stored in an iron chest, and left it untouched, living penuriously all his days. His capital, amounting to some thousands of pounds, was found intact in its safe after his death, thirty years from the time of its passing into his hands.

Hooke was one of the most extraordinary men of his own or any other age; the greatest mechanic of his era, a seer and prophet of incomparable clarity of vision.

"In person but despicable, being crooked and low of stature . . . he went stooping and very fast, having but a light body to carry." He frequently worked through the night, recruiting his faculties with a short nap during the day. He had many quarrels with his contemporaries, but even those quarrels were productive of good, for his challenges and impeachments impelled his protagonists to extend and amplify their researches, and drove even the mighty Newton to verify his calculations. Indeed, Hooke's theory of gravitation, reached intuitively, as it were, was adopted, and formed part of Newton's.

ELIAS HOWE

The Inventor of the Sewing-Machine

Elias Howe was born at Spencer, Massachusetts, on July 9, 1819. The inventor of the sewing-machine was the son of a small farmer, but he gained his idea for the sewing-machine in the works of a cotton-machine manufactory where he was employed. It was not any one machine that suggested the idea, but a general mastery of mechanical principles, and the knowledge that a sewing-machine was among the things most badly needed by the world.

Up to the time of Howe's invention every bit of sewing had to be done by hand. It was in 1841, when he was in very poor circumstances, that he first addressed himself to the task, and his labours have ever since been cited as among the highest examples of patient industry and devotion to a scientific task. Hard at work at the factory all day, and earning barely enough to maintain his little family, he laboured night after night, year after year, in a dismal garret, at model upon model. The principle was new to him, there was nothing to guide him, but the work became a passion with him, and he could not rest day or night for it. He had brought himself almost to beggary with the problem still unsolved—where was the eye of the needle to be placed?

His first plan was to let the machine-needle follow the plan of the needle of the seamstress, which has the eye at the heel, but this proved impossible. One night he dreamed that he was making a sewing-machine for a savage king, who gave him twenty-four hours in which to complete the machine, and make it sew—or die. In his dream he saw himself defeated, and led out to execution by warriors carrying spears—that were pierced through the head. He awoke with a start, for the problem was solved. Running to his garret, he pierced the head of a needle, and ran a thread through it, and the victory was gained.

But, of course, the mechanism of the machine was infinitely complicated. The first needle was curved, and was attached to the end of a vibrating lever, with which was combined a reciprocating shuttle for producing the lock-stitch. The needle had an eye near its point, and a groove along the upper and lower sides to allow of the thread lying safely, and so passing more easily to the cloth. The material to be sewn was fixed to pins on the edge of a thin steel rib, called a baster plate, which formed a portion of the feed mechanism for propelling the cloth, and was carried along, step by step, by the teeth of a small pinion, geared into holes made in the baster plate. An intermittent rotary action was imparted to the pinion, by self-acting mechanism working in concert with the needle and shuttle. Of course, this feed mechanism has long since disappeared, together with other archaic features. The cloth was held

in a vertical position against the side of the shuttle-race or groove by two strikers, carried on the ends of vibrating arms worked alternately by cams. An important and ingenious contrivance embodied in the machine was that which gave the requisite tension to the needle and shuttle threads, for taking up the slack in the needle-thread formed on the needle entering the cloth, for tightening and drawing up the stitch, and for supporting the cloth against the thrust and withdrawal of the needle.

Such, in brief, was the first sewing-machine ever invented. Primitive and crude as it was, that machine, the parent of all others, was destined to bestow a greater blessing upon housewives than almost any other mechanical invention that has ever been introduced into the home. It created huge new industries, by making cheap clothes possible, and by its use in a thousand directions of which its inventor never dreamed. The after-history of the machine was not wholly surprising. It proved at first a heartbreaking failure to Howe. Granted a patent for it in 1846, he could at the outset do nothing with it in America, so sold the English rights to a man named Thomas for £250, and himself followed the machine to England to adapt it to the making of corsets. He did not prosper, for in 1849 he had to borrow his passage-money to return steerage to America. He found his wife utterly destitute, and dying of consumption. His patent had been infringed, and others were making money rapidly out of the idea stolen from him while he and his family were starving.

MODEL OF HOWE'S ORIGINAL SEWING-MACHINE

But Howe had courage as well as genius. He fought the pirates, especially Singer; fought and beat them all, and fully vindicated his right to the invention brought with such labour and sorrow to what was then regarded as perfection. Weary days of poverty still lay before him, but at last the tide turned; and ten years after he had finished his machine he was in a position to dictate terms to all who had conspired to rob him. His position was once and for all established by the law, and there remained thirteen years for his patent still to run. For every sewing-machine in the world not of his own manufacture, the makers had to pay him a licence, and in that thirteen years of harvest he reaped a return of from £35,000 to £40,000 per annum. It was a splendid reward, comparable with that of Arkwright's. But there always remained in his mind the memory of the bitter days when he was bringing his invention to completion, and the cruel fate of his young wife, who was starved into consumption and death while his work was yet unrecognised.

Howe's original machine still exists, a crazy, clumsy-looking contrivance today, but still a wonderful little machine, considering the story of its creation. Howe died, a rich man, at Brooklyn, on October 3, 1867. If tailors and seamstresses ever decide to canonise a man, that man should be the inventor of the sewing-machine, and his style should be St. Howe.

DAVID EDWARD HUGHES

Inventor of the Microphone

David Edward Hughes, whose microphone made the telephone a commercial success, was born in London, of Welsh parentage, on May 16, 1830, but was taken, at seven years of age, with his family, to Virginia. He was educated at St. Joseph's College, Kentucky, and distinguished himself by musical talent and aptitude for natural philosophy—in fact, he taught both subjects until the electric telegraph called into play his faculty for invention.

There was in use in America a primitive form of type-printing machine, and Hughes, taking up the idea, devoted two years' study to it; then, when only six-and-twenty, brought out his own machine for

printing by telegraphy. The idea was at once adopted in America, but on his bringing it to England the powers that be viewed it with the same distrust that had been engendered by electric telegraphy in all its stages. The French Government, however, after thoroughly testing the invention, took it up gladly, and honours as well as riches were bestowed upon the inventor. Hughes stayed in Paris for some years; then, returning to England, established himself in London, fitted up a laboratory equipped with apparatus of his own fashioning, and within a year brought out his invaluable microphone, which at once superseded the Bell transmitter, and gave resonance and reality of tone to the human voice over the telephone, as well as investing the instrument with other interesting powers. The instrument is described at page 714 of this work.

Immensely important results should have followed from the discoveries made by Hughes in connection with the microphone. He was actually practising wireless telegraphy in the streets of London when Marconi was a child in knickerbockers! Hertz, who had proved the existence of the electro-magnetic waves which Clerk Maxwell had declared would be found, died saying that wireless telegraphy and telephony would never be possible, he feared, because the alternations of current in the telephone were too slow in comparison with the electro-magnetic oscillations. And yet, long before Hertz had made his discoveries, a man had been strolling about London actually using the very instrument which performed the "impossible" feat. The whole romantic story may be found in Mr. J. J. Fahie's "Wireless Telegraphy."

The microphone owes its action to the great variation of electrical resistance of a loose contact between two conductors, on the slightest relative movement of the two parts. Proceeding from his first invention, Hughes produced his remarkable "induction balance," in which a telephone replaced the galvanometer and current-rectifier. Extending this idea, he found that, by uniting the telephone to the coils of his induction balance, he made the former sensitive to a remarkable degree to the presence of metals—so much so that he could tell a good coin from a bad one by the sounds given out in the telephone. The extreme delicacy of the instrument was proved when the inventor located a piece of iron which had lain for thirty-five years in one of the fingers of Elisha Gray. It was with this or a similar instrument that Professor Graham Bell, the inventor of the telephone, sought to discover the whereabouts of the bullet lodged in the body of President Garfield. Proceeding with his researches, Hughes was for a time puzzled by the fact that at times he could not get a perfect balance in his induction balance, and thought that the defect lay in the fact that there was intermittent loose contact, or "microphonic joint," excited in some portion of the circuit.

He found that these microphonic joints

THE TYPE-PRINTING TELEGRAPH INSTRUMENT INVENTED BY DAVID HUGHES

were sensitive to sudden electric impulses, whether given out to the atmosphere through the extra current from a coil or from frictional machinery. Investigations showed that the microphone emitted a current or sound in the telephone receiver, whether the microphone was placed direct in the circuit or several feet away from the coils, through which an intermittent current was passing. He next ascertained that an interrupted current in any coil gave out at each such interruption such

intense extra currents that the whole atmosphere of the room, or rooms, would have a momentary discharge which was perceptible to the microphone. He had discovered the phenomenon on which depends the action of the coherer in wireless telegraphy, afterwards independently discovered by Lodge and Marconi. He then began experiments in actual wireless telegraphy, and Preece, Crookes, Huxley, and Dewar were among the first to witness his success. These experiments formed the basis of a remarkable article written some years later by Sir William Crookes, foreshadowing the coming of wireless telegraphy. Signals were transmitted through intervening walls from room to room.

Hughes himself afterwards wrote : " After trying successfully all distances allowed by my residence in Portland Street, my usual method was to put the transmitter in operation, and walk up and down Great Portland Street, with the receiver in my hand, with the telephone to the ear. The sounds seemed slightly to increase for a distance of sixty yards; then gradually diminish, until, at 500 yards, I could no longer with certainty hear the transmitted signals. What struck me as remarkable was that opposite certain houses I could hear better, whilst at others the signals could hardly be perceived. Hertz's discovery of nodal points in reflected waves (in 1887-89) has explained to me what was then a mystery."

Next, in February, 1880, his experiments were witnessed by the President and honorary secretaries of the Royal Society, who were at first astonished at the transmission of wireless signals over distances up to 500 yards, but, in the end, Sir George Stokes would not accept the inventor's theory that the results were due to electric waves. All the results, he said, could be explained by well-known electro-magnetic induction effects.

Hughes was disappointed at the scepticism of his friends, and " so discouraged at being unable to convince them of the truth of these aerial electric waves that I actually refused to write a paper on the subject until I was better prepared to demonstrate the existence of these waves. And I continued my experiments for some years, in hopes of arriving at a perfect scientific demonstration of aerial electric waves produced by a spark from the extra currents in coils, or from frictional electricity, or from secondary coils."

While he was still experimenting, Hertz discovered the electric waves in which Stokes disbelieved ; and because our professor in dudgeon refused to publish the results as to which his scientific friends were doubtful, the miracle of wireless telegraphy was withheld from the world until Marconi arrived and developed it. We might not even have heard of Hughes in connection with the magic story had not Sir William Crookes written his paper on the subject, which set all the scientific world talking and demanding the name of the author of the seemingly incredible experiments which, as he said (February, 1892), revealed the " bewildering possibility of telegraphy without wires, posts, cables, or any of our present costly apparatus." Hughes realised a large fortune, and, dying in London on January 22, 1900, left the bulk of £400,000 to London hospitals.

BENJAMIN HUNTSMAN

The Inventor of Crucible Steel

Benjamin Huntsman, the inventor of crucible-cast steel, was born, of German parentage, in Lincolnshire, in 1704, and, endowed with considerable mechanical genius, established himself at Doncaster as a clock maker and mender, and as repairer of a variety of mechanical implements. In connection with his work he made a number of ingenious tools, but for these, as for the springs and other parts of his clocks, he suffered from a lack of good metal, and set himself the task of himself providing the improved metal that he sought. He settled on the outskirts of Sheffield in 1740, and there began the experiments which were to increase the pre-eminence of that city as the centre of the steel-making world. How he reached his results cannot now be known, but Smiles, his biographer, who was stimulated to inquiry by a French memoir, the first publicly to recognise the work of Huntsman, tells us of the record of many misadventures.

Long after Huntsman's death, he says, the memorials of the numerous failures through which he had worked his way to success were brought to light in the shape of many hundredweights of steel, found buried in the earth in different places about his manufactory. From the number of these wrecks of early experiments it is clear that he had worked continuously upon his grand idea of purifying the raw steel then in use by melting it with fluxes at an intense heat in closed earthen crucibles. But success came in due season ; the first crucible-cast steel was invented, and it

remained but to sell it. It was offered in vain to the Sheffield manufacturers. The product was so much harder—and, of course, better—than any they had previously used that they would not touch it. Huntsman was not, however, long denied a market; he found ready purchasers in France for all his output.

Very soon French cutlery and other wares made of this new Sheffield steel were invading the Sheffield market, and the Sheffielders went in panic to their senior member of Parliament, beseeching him to get Parliament to prohibit the exportation of cast steel. When the gentleman in question heard that they themselves declined to use the new steel which was beating them in the markets, he was wise enough to refuse countenance to the petition. So, against their will, the men of Sheffield had perforce to buy the new metal which was available at their very doors, and Huntsman, his trade thus suddenly increased, found it necessary to remove to larger premises at Attercliffe, another Sheffield suburb.

Many attempts were made to fathom his secret. He must have been served by a particularly loyal set of workmen. They were all sworn to secrecy, and melted their steel only at night, and, though fantastic tales got abroad as to broken glass bottles used as a flux being the charm employed for the conversion of impure metal into this inimitable steel, those who sought to emulate him failed, until Walker, of Grenoside, began to produce its like.

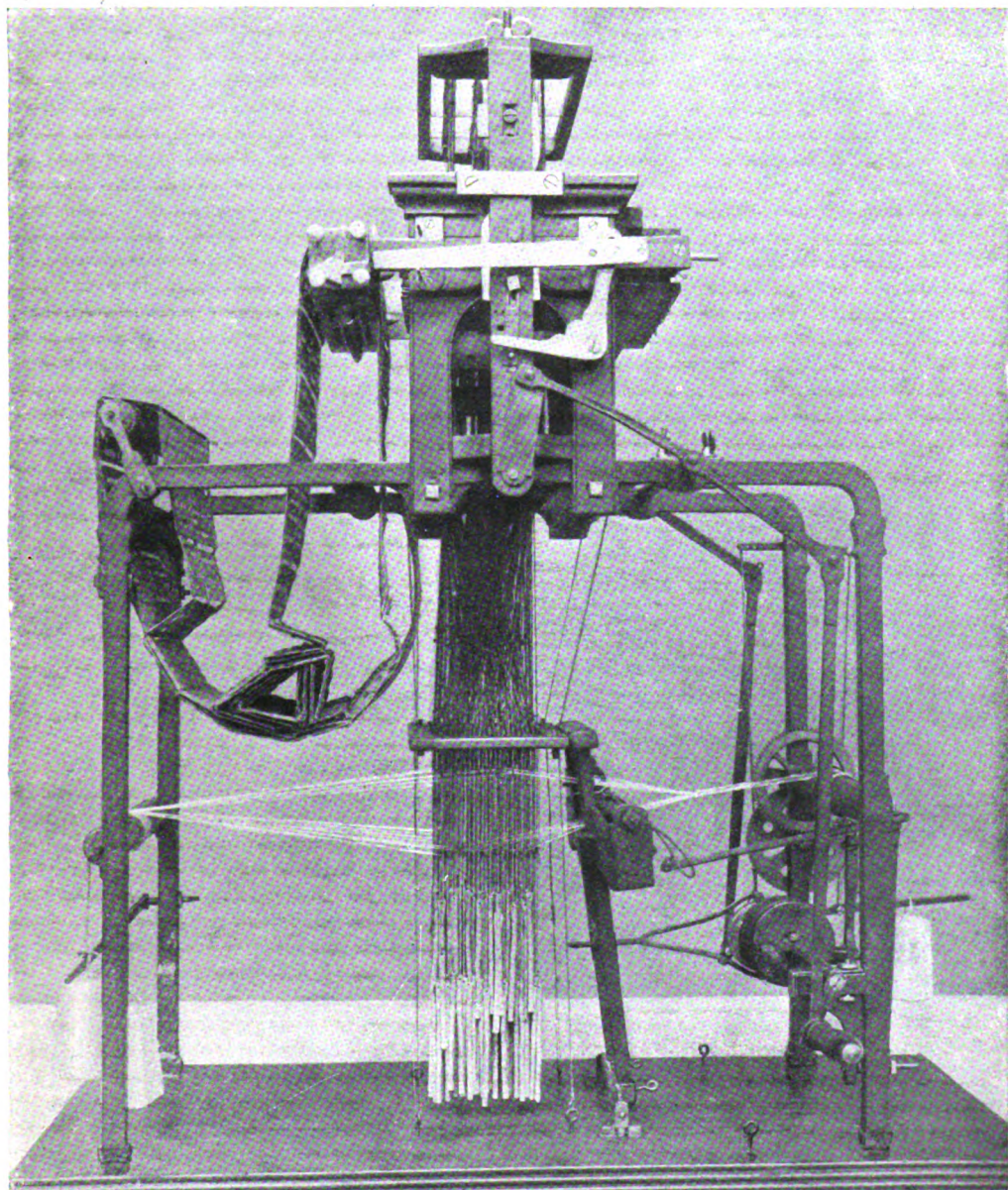
The story of his mastering the grand secret bears a suspicious resemblance to one told of the Potteries, but Smiles accepts it, having had it from the descendants of Huntsman. Walker, disguised as a tramp, presented himself at the works one bitter night, just as the workmen were about to begin their labours at steel-casting, and asked permission to warm himself by the furnace fire. Stirred to pity, they admitted him. He watched the whole process while feigning sleep by the fire. He saw that bars of blistered steel were broken up into small fragments, two or three inches in length, and placed in crucibles of fireclay; saw them add a little green glass, broken into small fragments, cover the whole with a closely fitting cover, and place it in a furnace already prepared. In the course of three or four hours, during which the boiling metal was examined from time to time, the steel was thoroughly melted and incorporated, and then at last poured, blazing and sparkling, into moulds of cast iron, where it was suffered to cool.

Very soon afterwards Walker himself began the manufacture of crucible-cast steel. The industry was of prime importance to the steel-making industry as a whole, and to Sheffield in particular. At the very time that the Sheffielders were agitating against him, Huntsman was considering a handsome offer from Birmingham to set up his works there. Had he gone, Sheffield might have had a very different tale to tell today, and Birmingham might have been the steel capital of the world. Huntsman, who was a man of considerable learning, and in his youth acted, con amore, as doctor and oculist to the poor about him, amassed a handsome fortune, and handed on a famous business to his son. He died in 1776, and was buried in Attercliffe churchyard, to which his French biographer, who was the first to direct attention to his merits, made a pious pilgrimage to copy the dates of his birth and death for the report he was presenting to his Government. In this case we have had to go from home to learn the news of one of the worthiest of our industrial pioneers.

JOSEPH MARIE JACQUARD

Inventor of the Pattern-Making Loom

Joseph Marie Jacquard, inventor of the loom which bears his name, was born at Lyons in 1752, the son of very poor silk-weavers. The misery of his own household caused him to revolt against the calling until, as he said, such time as he was able to invent a better loom which should do superior work at less cost in labour to the operative. But the need for bread caused him to accept such employment as was at hand—that of bookbinder, type-founder, hat-maker—so that it was not until he had reached middle age that he was able to indulge his latent genius for mechanics. And then the revelation of his talent was due to accident!

In 1802 the English Society of Arts offered, with apparently small chance of success, a handsome prize for a lace-making machine, or one that should be applicable to a certain process of thread-weaving. A French translation of the announcement reached Jacquard, and in his spare time he constructed a model, but thought too little of it to claim the reward—so many other minds must have designed something of the sort, he imagined. But a fellow-workman realised the value of his invention, and, borrowing the model, showed it

MODEL OF A LOOM WITH JACQUARD'S APPARATUS ATTACHED TO IT

to the prefect. The latter, wiser than the generality of his order, at once despatched the model to Paris, whither Jacquard was bidden speedily to present himself.

He went in fear and trembling, expecting nothing less than the guillotine for some crime that he had not committed, but was received not by M. de Paris. Napoleon, at that time First Consul, and rough-tongued Carnot awaited him at the Conservatoire des Arts et Métiers. "Are you the man," asked the Organiser of Victory—"are you the man who pretends to do what God Almighty cannot do—tie a knot in a stretched string?" The frightened Jacquard could only reply that he could not do what God could not do, but what God had taught him to do. Encouraged by Napoleon, he explained his plan; and this, when perfected, gave us the loom for silk and lace and other fabrics. Essentially the Jacquard loom consists of perforated cards in connection with a revolving cylinder, which brings about this result—that if a wire or needle

with a particular warp-thread passes through a perforation in the card, it is taken up and forms part of the pattern; otherwise it is detached. The precise arrangement of the perforations constitutes the pattern. By this invention the ordinary workman is enabled to produce beautiful and complicated designs, which previously required almost incredible patience, skill, and labour.

Napoleon was highly pleased with the inventor, and appointed him forthwith to the Conservatoire, where he perfected his machine, and had the oversight of all the weaving, and especially of the weaving of intricate patterns. Napoleon could command and inspire armies, but he could not command the unruly prejudices of the work-people. The "no-machinery" virus was as

JOSEPH MARIE JACQUARD

malignant in France as in England. When Jacquard exhibited a perfect machine to the Conseil des Prud'hommes of his native town, they ordered that it should be publicly destroyed, and it was demolished in the market square, amidst the shouts and rejoicings of the mob. Jacquard was declared to be a man worthy only of contempt and ignominy, and thrice he narrowly escaped with his life. The invention passed to England, where it gave a great impulse to trade. Then in self-defence the French were compelled to adopt the invention which they had reviled. Jacquard, who was of a forgiving and complaisant disposition, forgot his wrongs; at once came forward and superintended the improvement and manufacture of his loom. He enjoyed a modest competency from the municipality of Lyons, for whom he carried out the work, and refused tempting offers from strangers to devote his services to them, saying that he preferred to consecrate all his time and such abilities as he possessed to the service of the town, and to perfect, as far as possible, his former inventions.

He lived to see his loom in general use, and, disdaining wealth, found his reward in the fact that he had given to the world a machine which emancipated the workers from the toil and penury of which his own father, mother, and starving sisters had in his boyhood been victims. Jacquard, a very notable figure in the annals of invention, died in 1834 at Lyons, where a statue now stands to keep his name and memory constantly before the community whose ancestors he so unselfishly benefited. When Jacquard died, the then tiny town of Coventry and the adjoining villages had no fewer than 2230 of his looms at work.

JOHN KAY

The Inventor of the Fly Shuttle

John Kay, the inventor of the fly shuttle, was born at Walmersley, near Bury, Lancashire, on July 16, 1704. His father, a woollen manufacturer, seems to have given him the advantage of an educational tour on the Continent, and, upon his return, to have placed him in charge of his business at Colchester. It was at Bury, however, that Kay was destined to become known. Weaving at this time was conducted very much on the same principle that had been employed from the earliest times. Indeed, the cotton wrappings of mummies taken from Egyptian tombs are said exactly to resemble the cloth made in Yorkshire, Lancashire, and elsewhere at this time. No mechanical genius had ever looked into the process. Kay was the first to bring his mind to bear upon the subject. The shuttle in use was one worked by hand. The weaver had to pass it by hand through alternate threads of the warp, passing it forward with one hand, catching it at the end of its journey with the other hand, and with that returning it across the warp. Kay's invention was a shuttle that required the use of only one hand, and it further closed up the weft by a self-acting mechanism. The Kay shuttle worked with great rapidity; hence its name, "fly" shuttle. The weaver was spared half his labour, and did at least twice the work, and of much better quality. The patent was taken out in 1733, when the inventor was only twenty-nine years of age. The importance of the fly shuttle was at once seized upon

by the manufacturers of the time, to whose trade it brought an undreamed new power. But, with the studied insolence which greeted all the early inventors in the cotton and woollen trades, they refused to pay for their treasure. Nay, more—they had the audacity to form themselves into what they called "the Shuttle Club," whose sole object was to present a united front to Kay upon his proceeding against them for the theft of his patent. He was compelled in self-defence to proceed, and of course gained decisions in his favour, but at such ruinous cost in legal fees that he was impoverished by the actions. The workmen, not satisfied with the iniquitous conduct of their masters, also rose against the luckless inventor. Their plea was that, although the new invention enabled them to do more work in a given time, there was no more work for them to fill in the intervals, and their wages were lessened. Moreover, their numbers were decreased, for whereas with the old hand-thrown shuttle two men were required for a broadcloth, now one could manage. Such was the plea in this instance, but any argument sufficed in that day to justify a machine-smashing campaign such as was now organised. They caused Kay to close his workshops, then broke into his house, demolished everything he possessed, and would have killed him had not friends smuggled him away to a place of safety, swathed in a package of wool.

Kay invented a power-loom which failed, as is supposed, from his lack of the funds necessary to bring it to perfection, while improved pumps and an ingenious card-making machine were as unfortunate. He fled to France, where he is said to have worked some of his machines which had been earlier smuggled out of the country. Encouraged by the British ambassador to return to England and once more challenge fortune, he was broken-hearted to find his invention everywhere employed, creating wealth for everyone concerned but himself. A letter still exists which, there can be little doubt, he addressed to the Society of Arts. "I have a great many more inventions than I have given in," wrote this unhappy genius, "and the reason that I have not put them forward is the bad treatment that I had from woollen and cotton factories in different parts of England, twenty years ago. And then I applied to Parliament, but they would not assist me in my affairs, which obliged me to go abroad to get money to pay my debts and support my family."

Hopelessly baffled and crushed, the luckless Kay retired finally to Paris, where he died in poverty and obscurity upon a date unknown. His biographer, in an estimate of the value of Kay's gift to his times, remarks: "Kay's improvements in machinery for weaving continue in use to the present day; they form a part of each loom actuated by power, of which there are tens of thousands in this kingdom alone, forming cloths of silk, cotton, linen, and woollen. He was the founder of the first great improvements in the manufacture of cloth, by which employment is now given to hundreds of thousands of people, and to millions of pounds sterling." Parliament was approached during the latter half of the nineteenth century on behalf of indigent descendants of Kay, but, although the full story of his inventions was presented, nothing resulted. Yet there were men in that Parliament whose ancestors owed every penny of their wealth to Kay's invention.

SAMUEL PIERPONT LANGLEY

Who First Made the Power-Driven Aeroplane Fly

Samuel Pierpont Langley, astronomer and inventor of flying-machines, was born at Roxbury, Mass., U.S.A., on August 22, 1834. In the early part of his career this famous American man of science displayed an uncommon versatility of talents. Having passed through the Boston High School in 1851, he took up the study of civil engineering and architecture, and practised these professions as a means of livelihood. He had a strong bent towards astronomy, and all his leisure time was devoted to the study of the science by which he afterwards won his fame. He made enough money at thirty to be able to afford to travel through Europe, visiting observatories, and mingling with men of science.

He returned to America with the intention of devoting himself entirely to scientific pursuits. At some sacrifice he accepted in 1865 the position of an assistant at the Harvard College Observatory, but soon afterwards his means were somewhat enlarged by an appointment as assistant professor of mathematics in the United States Naval Academy. Then came the chance of his life. The directorship of the new Alleghany Observatory at Pittsburg was won by him, and he was able to last to throw himself into the work in which from a boy he had been passionately interested.

He became known to the general public in 1868 by his services to the Pennsylvania Railway. He arranged to establish standard time on this railway by taking

observations of the stars, and telegraphing the exact astronomical time all along the line. The use of local times was then universal in the United States, even in the railway services, and confusion and accidents were frequent and inevitable. By his method of signalling his astronomical observations, Langley put an end to the confusion over the area stretching from the Atlantic seaboard to the Great Lakes. His system was so successful that it was soon widely imitated.

In some way the young astronomer was not fortunate in his early studies of the stars. The sky of the region where he was settled was so smoky and so misty that his observations were often interrupted, but with characteristic ingenuity he turned this disadvantage into a source of inspiration. Finding that the stars were hidden from him at night, he resolved to make the study of the sun the main work of his life. So he began that fine series of researches into the physics of solar radiation with which his name has become most closely associated. In 1869, in 1870, and in 1878 he directed the Government eclipse expeditions, and, by ascending on the last occasion Pike's Peak, he discovered that the corona visible in an eclipse of the sun is much larger than had been thought. His drawings of sunspots, made before the days of solar photography, contained all that the unaided eye can see of the surface of the flaming centre of our planetary system.

From 1875 he had given much attention to the problem of the invisible heat-rays from the sun and other hot bodies, but he was impeded by the crudeness and inaccuracy of all instruments used for measuring heat. Aided by a grant from the Rumford Fund, he set to work in December, 1879, to invent an apparatus for studying the invisible heat-rays of the sun.

This was the first work of importance in which his fine inventive genius was displayed. The outcome was the famous bolometer, which is so sensitive that it can register the heat given off by a single candle at a distance of a mile. In his first design two strips of thin metal were connected by the wire from an electric battery. In the ordinary way the current passed through the strips of metal in a regular flow, and the galvanometer did not move. But when one of the strips became slightly warmed its electrical resistance was increased, and the effect was seen in the movement of the galvanometer. In its final form the bolometer consisted of two sets of metal strips arranged somewhat like a grating. The strips were made of platinum, only 1-1500th of an inch thick. With this instrument Professor Langley explored the infra-red portion of the spectrum of sunlight.

As is well known, the solar spectrum consists of a band of rainbow colours on which there are thousands of faint dark lines. These dark lines represent the elements flaming in the heart of the sun, and rolling up in clouds of gas on the surface. Beyond the red part of the spectrum is an invisible portion in which most of the heat-rays are found. But the trouble is that the colour cannot be seen, so the fine lines, of course, are still more invisible. Langley set himself to make out these invisible lines on an unseen band of infra-red colour. He did it by means of his bolometer.

He sent a ray of sunlight through a prism, and so broke it into an ordinary spectrum, and then let a tiny part of the infra-red rays strike on his bolometer. He could tell when he came to a line by the fact that the lines were colder than the rest of the invisible hot end of the spectrum. But the work was so laborious that it took him two years to fix the position of twenty lines. This was much too slow, so he improved his recording instruments, and made them practically automatic. In this way the work of two highly trained observers was saved, and by moving everything simultaneously by clockwork the labour of exploring and measuring the invisible heat-rays and lines was much expedited.

Having thus perfected his instrument, Professor Langley put it to new uses. He took one of the large and brilliant fireflies of Cuba and sent its light across a spectrum, and examined the red end with his bolometer. He found that there were no infra-red rays, and that even the ordinary red rays were lacking. He thus showed that light-producing insects manage easily to do what man as yet cannot—create light without heat.

In 1887 Professor Langley became secretary of the Smithsonian Institute, which officially represents the interests of the United States in pure science. His new position gave him the opportunity for working at a new problem, which he had long had in his mind. This was the problem of mechanical flight. He saw that what was needed was the experimental study of the conditions bearing in the behaviour of bodies in motion through the air. He published his first "Experiments

in Aerodynamics" in 1891, and followed this up by an important paper on "The Internal Work of the Wind."

All these preliminary researches satisfied him of the possibilities of mechanical flight, so for several years he worked at the design and construction of small flying-machines in his private workshop at the Smithsonian Institution. In 1896, for the first time in history, he launched a mechanical structure free of any attachment to the ground, and without any supporting power but its own engines. It made several flights, each over half a mile in length. Having thus demonstrated both the conditions and the possibility of mechanical flight, Professor Langley let the matter rest for some time.

He had shown, from a scientific point of view, that the flying-machine was an actuality, and, busy with his spectrum studies, he left the field open for practical inventors. Later on, at the desire of the American military authorities, he continued his researches and experiments. He built a quarter-scale model of a full-sized machine, which made quite a remarkably good flight. And there can now be little doubt that, had any daring aviator taken up his invention, it would have been a practical success. All that was needed at the time for the success of the full-sized Langley machine was a launching device. The aeroplane itself was a complete success, and possessed a great inherent stability. Even now, if some person were to put the finishing touches to Langley's inventions and give them to the world, it is quite likely that the machine would stand comparison with anything done since Langley's experiments were interrupted. The most striking feature of Langley's work is its remarkable originality. In attacking the problem of flight he took nothing on trust, but worked out everything by experiment.

He was defeated by the prohibitive cost of his last experiments. He made a full-sized man-carrying flying-machine, which was wrecked owing to defects in the launching apparatus, and to no fault of the aeroplane. The expense of his experiments was so great that he could not carry them any further. Nevertheless, his work has proved of fundamental importance in the study of aeronautics, and it cleared the way for later men. Langley died in 1906, three years after his indefatigable countrymen the brothers Wilbur and Orville Wright made their first voyage on a motor-propelled machine and started a new mode of locomotion.

NICOLAS LEBLANC

A Creator of Wealth who Died in Poverty

Nicolas Leblanc, the discoverer of the artificial soda that revolutionised and cheapened many important industries, was born at Ivoy-le-Pré, in France, on December 6, 1742. He came of poorish middle-class parents, who were unable to give him a good education in boyhood, but at seventeen he was able to go to Paris and study surgery, medicine, and chemistry at the College of France. He seems to have owed his early success in life to the fact that Berthollet was one of his fellow-students. For when Berthollet became doctor to the Duke of Orleans, Leblanc was also appointed surgeon to the royal prince.

Like Berthollet, he was much interested in chemistry, and he worked for some time on the problems of crystallisation. His attention was turned to the manufacture of artificial soda by a prize offered by the French Academy of Sciences for the best method of converting common salt into soda. This had become a pressing need in many industries, and a vast fortune seemed to await the man who could break common salt into its elements of sodium and chlorine, and employ the sodium in the manufacture of alkali. Practically all the soda then used in glass-making and other manufactures was a costly product, made from the ashes of plants.

Leblanc discovered his process in 1787, and two years afterwards he entered into a partnership with the Duke of Orleans for the establishment of a soda factory. The Duke provided £8000 as the capital of the undertaking, on the condition that he received 70 per cent. of the first profits. A factory was erected at St. Denis, and it at once proved a prosperous concern. Unfortunately for Leblanc, the Duke of Orleans was executed in 1793, and his property, including the factory, was confiscated. The Terrorists not only stopped the manufacture of artificial soda, but cancelled Leblanc's patent, and called upon him fully to reveal his process, so that the new industry could be carried on for the benefit of the State. In order to save his life, the inventor had to furnish an accurate description of all the particulars of his processes. But, instead of keeping the factory open, the Revolutionary Government closed down the works, and sold the building without any indemnity to Leblanc.

The inventor, who had married and had children, was reduced to extreme poverty at the moment when his process had become

a source of wealth and factories were being erected to work it. For seven years Leblanc vainly tried to recover damages for the injury done to him by the Terrorists. At last, in 1801, his ruined factory was restored to him and his partner, Dizé, and a promise was made to grant him a sum of money to repair the works and enable him to resume his business. But all that was given to him was a loan of £80 in 1803, and a miserable dole of £12, together with a "national recompense" of £24! Even the verdict of two Government arbitrators, who awarded Leblanc over £2000, was set aside, and the inventor was informed, in November, 1805, that his claim must be considered as settled by the return to him of his decayed, worthless factory. Broken in health and spirit, Leblanc returned to his sick wife and starving children, who were living in the ruined works. On January 16, 1806, his mind gave way, and he shot himself.

There can be no doubt whatever that Leblanc would have made an immense fortune if his factory had not been confiscated and his patent revoked. Many millions of pounds have been made by men who adopted his process. It consisted of treating common salt with oil of vitriol, thus producing sulphate of soda. The sulphate of soda was burnt, and mixed with half its weight of chalk and a quarter of its weight of charcoal—coal being substituted for charcoal in England. The mixture was finely ground, and placed in a pot and heated until it fluxed. The fluxed mass was purified by powdering and boiling with water, and on boiling down the soda was separated from the solution and dried in hot air. By later improvements the sulphur was recovered, and the chlorine also was obtained in the form of hydrochloric acid for bleaching purposes. The Leblanc process was an important factor in many industries for three-quarters of a century, and the money made by it was enormous. It has recently become antiquated by a new method of separating common salt into sodium and chlorine by means of an electric current.

JOHN LOUDON McADAM

The Reviver of Sound Road-Making

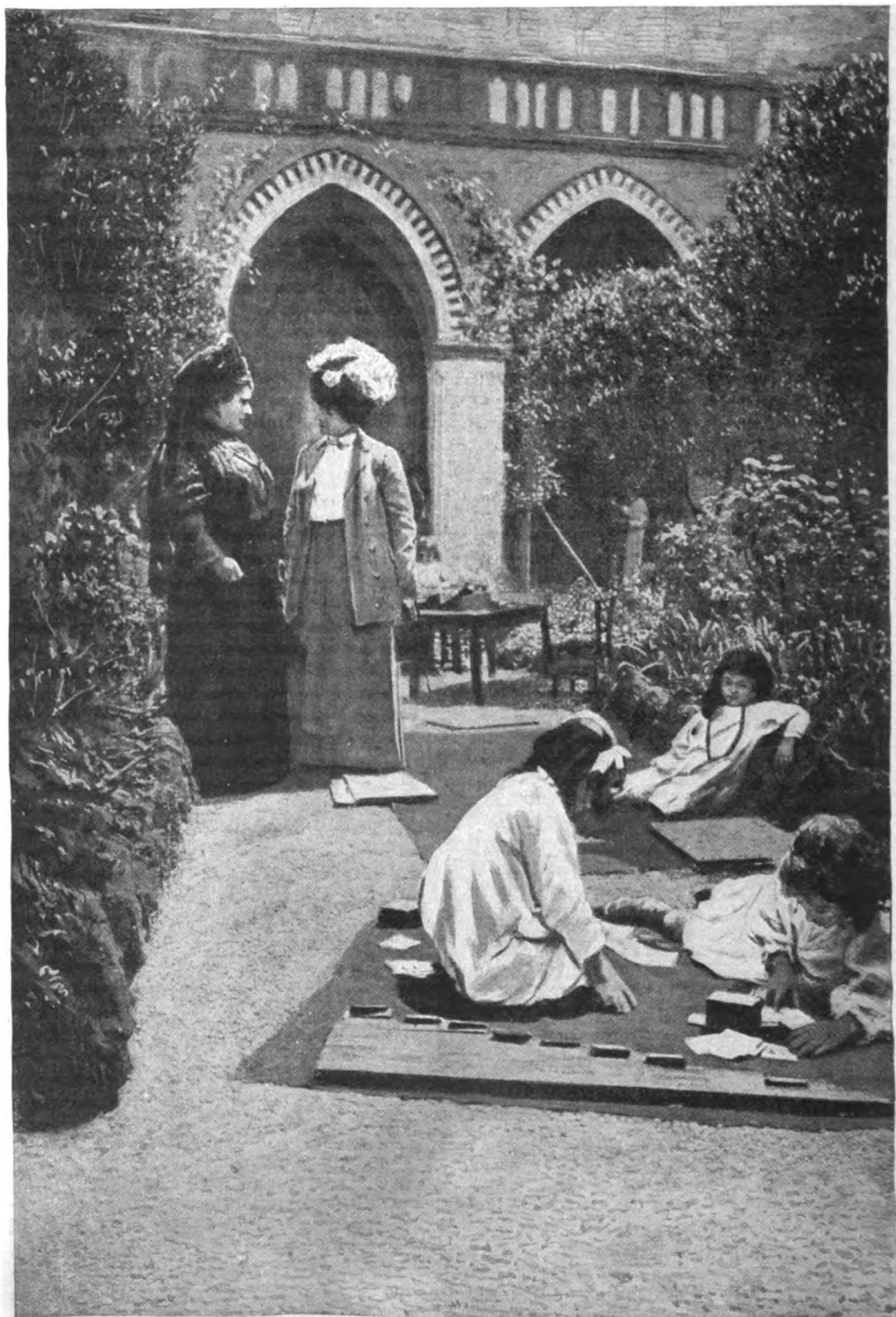
John Loudon McAdam, who, with the illustrious Telford, was the greatest road-builder since the time of the Romans in Britain, was born at Ayr on September 21, 1756, his father, a man of substance, being the first banker in that town. As a boy, instead of toys, he made model roads! Following the death of his father, in 1770, he spent some years in America in the care of an uncle, and returned with sufficient money to buy an estate in Ayrshire, where he was able to indulge to the full his desire for experiments with road-making. There was need of such a man, for Telford had not yet begun his splendid highways. The roads of Great Britain were the worst to be found in any important country in Europe. There had not been a brain behind the subject since the Romans planned their noble highways. Their work still remained, but, all told, there were at this time only four tolerable turnpike roads in England, and the condition of even these was such that, when the Post Office issued instructions that the mail must run from London to Holyhead in thirty-eight hours, Hasker, the experienced and worthy superintendent of mail-coaches, protested in writing against the "extraordinary expedition projected," declaring that it would be inhuman to horses and highly dangerous to life. Yet all that was asked was an average speed from a four-in-hand of seven miles an hour!

But we in this day can scarcely picture what the roads before McAdam's time really were like. London roads were so bad that in wet weather the best-horsed coaches could not do the journey between Kensington and St. James's Palace in less than two hours, and often enough coaches became bogged on the way. Indeed, on one occasion Parliament was without its Speaker, the First Commoner being hopelessly mired in his attempt to reach the House. McAdam altered all that. But his task was worse on the main roads out in the country. These were simply developments of the old footpaths and cattle-tracks of an earlier day, and, to avoid bogs and marsh lands, they invariably followed the hills. The highways were practically widened bridle-paths, along which coaches had precariously to make their way. The roads had no proper foundations, no suitable or sufficient materials upon their surface; and not the least attempt was made at drainage; hardly any had gutter channels. Frequently the sides were encumbered by huge embankments of mud which accumulated to a height of six, seven, or more feet. The middle of the road was generally cut into deep ruts, which in wet weather fixed the mail-coaches up to their floors in mud. The sort of thing that the mail service had to contend with may be inferred from extracts from a report made to the Post Office as to the Holyhead main road in the days which brought McAdam into action:

"To Kenneage, six miles of narrow road, scarcely room for two carriages to pass, and much out of repair; in winter the drivers say the ruts are up to the beds of the coaches. . . . From Kenneage to Capel Curig, road narrow, and wants walling to prevent carriages falling down precipices 300 or 400 yards perpendicular. . . . From Capel Curig to Bangor, side of the road unguarded, and many accidents may happen to passengers by the coach running off the road as the mail passes here in the dark."

While the great Telford was causing "the valleys to be exalted and the hills made low, the crooked straight, and the rough places plain," McAdam was carrying on his private experiments in road-making, seeking for the ideal material. Appointed an agent for revictualling the Navy in the West, he took up his residence at Falmouth, and there extended his experiments; and when eventually he gave evidence before a Parliamentary Committee on the subject he was able to make the surprising statement that between 1798 and 1814 he had travelled over thirty thousand miles of roads in Great Britain, and spent two thousand pounds in order to pursue his investigations. He expounded his plan, which was simple enough. It was to make the surface of the road of broken granite, no piece to weigh more than about six ounces, or be too large to pass through a 2½-inch ring. He asked for no artificial foundation, such as Telford used, but said that, if the bed were just hard enough for a man to walk over it, his ten inches of granite, being angular, would knit and bind together, and form an enduring, smooth, and almost watertight surface. The assembled roadmakers who were present at the hearing laughed loudly, we are told, at the suggestion of this amateur, but the members of the Committee were impressed by the earnestness of the man and the elaborate precautions he had taken before expressing himself upon the subject.

An experiment was made, and the upshot was that McAdam was appointed Surveyor-General, first of the Bristol roads, and ultimately of roads for the entire country. He gained an immediate and immense success. He cut down the absurd and dangerous camber of the town roads, which, to prevent water from collecting in the centre of the highway, presented a slope downward from the middle like the roof of a house—an inexcusable tendency which is being imitated upon many main roads today. He made his roads slightly but sufficiently convex to maintain dryness, he cut away hedges and rank vegetable growths to enable the roads to get air and to dry by process of evaporation. He made his surfaces practically watertight. The latter-day macadamised roads, which proved a failure under motor traffic, for which they were, of course. never designed, would not have cut up so badly had his scheme been followed of laying on good granite of uniform size. No man had ever previously wrought a greater revolution than McAdam in a nation's commerce in the matter of traction. He gave us roads and there were many men to put speedy coaches on them. Trade between town and town and county and county immediately underwent a great expansion, and it has been said that McAdam clearly prepared the way for the railways. The steam locomotive, of course, minimised the importance of his roads for many years, and as a nation we were beginning to lose the art of road-making again until the motor-car arrived, and created a new need. Between the coming of the train and the motor-car the roads had been neglected, just as the canals were neglected, and we have suddenly needed both again. Scores of engineers are now concentrating on the task of providing new surfaces for our highways. The macadamised road, tarred by various processes, is still the great highway north, south, east, and west, and, with modifications, probably will so continue.

The term "macadamise" is now in universal employment. The macadamised road is the pathway of all civilised countries; and when the centenary of the inventor's first road appointment arrives, in 1915, possibly we shall be given some estimate of the actual mileage of main roads in the Old World and the New by which his art is represented. Probably the future road will make the macadamised part the middle stratum. With the enormously heavy and fast traffic that our streets and roads now have to carry, we can no longer trust to soft foundations. We shall, it is likely, employ the Telford principle, or something like it, for the foundation, with macadam as the main body-substance, faced by a preparation of tar or other binding and waterproofing material. McAdam, whose interest in his work was above pecuniary considerations, declared that he would die a poor but honest man, and he did. He received £10,000 in all from Parliament, and declined a knighthood. He died at Moffat, Dumfriesshire, while out on a road survey, on November 26, 1836.

DR. MONTESSORI (ON THE LEFT) VISITING A ROMAN SCHOOL TAUGHT ON HER SYSTEM

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PIONEERS

KARL MARX

The Economist of Modern Socialism

KARL MARX, the thinker who laid the more solid foundations of modern Socialism, was, like his co-worker Ferdinand Lassalle, of Jewish origin, and, again like Lassalle, sprang from a well-to-do stock. His father was a lawyer, named, not Marx, but Mordechai, and the son was expected to join the same profession after an education at Bonn and Berlin. He had been born at Treves on May 5, 1818. His taste did not, however, accept the law, and at the age of twenty-four he was embarked on the career of journalism as editor of the Socialistic "Rhenish Gazette." Later he was connected with "Vorwärts," an organ that has played a conspicuous part in Socialistic agitation in Germany. By the time that he was thirty-one, Marx had made the Continent too hot to hold him. He had been expelled from France, Belgium, and Germany, and sought a refuge in England, the asylum of contentious causes, and he lived in London for thirty-four years, till his death on March 14, 1883.

Before coming to England he had organised, in Brussels, the Communistic League; and while here he founded the "International," or International Working Men's Association, an organisation that passed through interesting vicissitudes, including a period of very considerable influence, but lost its importance when it fell into the hands of the Anarchist section under Bakunin.

Karl Marx was unquestionably the man of greatest intellectual weight who has associated himself with the Socialist propaganda, and his writing, concentrated in the book "Capital," has had a very far-reaching and profound effect on working-class thought in this country. "Capital" is the Bible of the intelligent Socialistic working man. He knows it thought by thought, to the undoing of opponents who talk at large, without that special study of economics which shows the limitations of the theories of Marx.

A most important feature of the writing of Marx is that it is much more than political and social economy in the eyes of those who believe. It is a religion and a prophecy. Marx reared his economic edifice on a foundation of history—the history that regards the story of man as a scientific evolution. He argued that the story of modern capital, and its command over men and the world, begins with the sixteenth century, and has had clearly traceable evolutionary phases. It has grown through conditions that came into existence unrealised at first; it has culminated in great wealth for the comparatively unproductive few, and poverty and anxious strain for the productive many, and it is moving on, inevitably, to a catastrophic overthrow. Evolutionary laws, as certain as the rising of tomorrow's sun, will destroy the present economic system, and usher in a new kingdom, wherein economic processes will be carried on, for the good of all, by the State. In those days Governments will no longer be concerned in keeping the people who labour in subjection, but will control all labour and will ensure that it reaps its just reward. Such a gospel as this is more than a dry economy. It is accepted as an inspiration and a hope. Its significance extends far beyond material things, for Marx believed that economic conditions supply the nurture for all human developments; and the life of man would be broadened and ennobled by the success of the ideas which he formulated.

It does not concern us here to examine the Marxian conception of capital—a conception that admittedly is so narrowed as to make it little except a cruel oppressor, "that comes dripping from head to foot, at every pore, with blood and dirt"—but no one who is unacquainted with the book can pretend to have a command of the

essentials in the most vital economic controversies of our age. Like all prophets who try to foretell human evolution, Marx has been proved wrong in some respects by the inexorable logic of events, but far oftener he has proved right, and has forecast the problems that are arising in our midst, as, for example, the enormous power of Trusts, which threaten to break mankind if they cannot be broken or controlled.

LORD MASHAM

Perfecter of Woollen-Trade Machinery

Samuel Cunliffe Lister, created in 1891 first Baron Masham, was born at Calverley Hall, near Leeds, on January 1, 1815. His father, Samuel Cunliffe, who successively adopted the names Lister and Kaye, was a wealthy manufacturer, and sat as the first member of Parliament elected by the borough of Bradford. It was at Bradford that Masham grew up, and there that his memorable experiments were carried out. Masham, although only the fourth son, was marked out to quit the commercial pursuits of the family; and his grandmother having bequeathed him the living of Addingham, it was intended that he should enter the Church. But the young man's mind was fired by the story of the spread of steam power, and of inventions coming into existence to revolutionise industry in all its branches, and, rather than devote himself to the cloistered seclusion of a country parsonage, he voluntarily became a clerk in a Liverpool mercantile house. While thus occupied he made several voyages to America; and as to cross the Atlantic in those pre-steamship days was a prime adventure, the youth attained quite a reputation for daring, and was known for many years as "American Sam."

His versatility and independence, as well as his knowledge of industrial processes in the West, gave him some title to the name, and his subsequent career still further emphasised its aptness. Although, as we have seen, Cartwright had already invented a wool-combing machine, the scheme had not been brought to success. Indeed, Cartwright's progress in the matter had but made men realise how desirable was the perfect machine, and many sought it with the zeal of the alchemist for the philosopher's stone, and with corresponding result—beggary. Lister took up the idea when his father started his brother and himself in a mill of their own at Bradford. The brother did not long remain in the business, and Lister had a free hand.

Donisthorpe's machine had gone nearest to success, but it lacked that little which means the *all* of success. Here, he saw, was the germ of the idea, and he bought, first the half patent-right for £2000, and then the whole for £10,000, only to make the astounding discovery that he possessed practically the duplicate of the machine invented by Cartwright himself!

Donisthorpe worked for some time with Lister, but the latter, in conjunction with Isaac Holden, invented the "square motion" machine, a machine which, he acknowledged, went but little beyond that of Cartwright. That little was important, and the machine has not yet been superseded for its special purpose, although it dates from 1848. Next followed Lister's process for combing and carding fine wool, which reduced the cost of manufacture by six-sevenths, and created such a demand for wool that Australia at once felt the effects.

Britain could not furnish the necessary supplies; we had to seek fresh woods and fleeces new; and, by developing the Australian wool trade, the invention quickly became one of Imperial value. The trade in the machines manufactured from Lister's patents at once brought him a handsome revenue. Admirable as manufacturers found them, and economical as they were to work, their sale yielded the inventor a profit of 600 per cent. The woollen industry was at once enormously stimulated; and cheap, good clothes were for the first time placed within reach of the English people.

While busy with this matter, Lister invented a pneumatic brake for railways, but the time was not ripe for the scheme. It remained for Westinghouse, twenty years after the expiry of the Lister patent, to bring out that brake, and at once capture the railway world's imagination. Lister derived neither profit nor kudos from his brake. His attention was quickly diverted, however, to the biggest task of his life. While in a London warehouse he was shown a heap of ill-smelling, sticky rubbish, which, he was told, was the waste from cocoons of the silk-moth caterpillar. No one had thought of using it; it was waste in every sense of the word. He bought the consignment at a halfpenny a pound, and began his twenty-five years' experiments. As a bow at a venture, he put some of the filthy mass through one of his combing-machines, and found to his surprise that it could be converted—very imperfectly, of course—into the very thing the silk merchants desired—a continuous sliver of silk.

The difficulty now was to invent machinery to do perfectly the thing which the wool-comber had done crudely as an illustration of possibilities.

Lister was at the time a wealthy man, with mills in England, and others in France and Germany, and might well have afforded to leave silk waste alone. But the problem challenged his skill and pertinacity; the more he experimented and failed, the more determined he became to master it. Machine after machine was made throughout the years of trial, and, great as were his resources, he was brought by his quest within measurable distance of bankruptcy.

LORD MASHAM
From the sculpture by Alfred Drury

When the books came to be checked, and all accounts made known, it was found that £360,000 had been spent upon the process, and not a penny return was yet in sight. Still the indomitable Yorkshireman kept on, and at last he succeeded. His silk-comb was a triumph exceeded only by his later product, the self-acting dressing-frame.

The many experiments that he made in relation to this machine were not all wasted. Out of them emerged a machine for utilising the silk waste as velvet and plush. Many attempts had been made before, with disastrous results to experimenters. Lister did not easily win his way. Before he brought his machine to perfection, he found that he had been spending on it £4000 a year for seven years. But, as he said, he knew that he was in for a good investment—at least, £50,000 a year—and he risked his money on his faith in himself. All came right in the end, and he realised a huge fortune for himself, while creating—or, rather, restoring—a lost industry to England. Velvet-making had passed from her hands; it now came back at the instance of this ingenious and courageous inventor.

Both the woollen and silk industries began again as the outcome of Lister's work, and no one grudged him the great profits he realised. His business, when converted into a limited liability, was capitalised at all but two millions sterling. Up to that time Lord Masham had been for many years the head of the largest business in the world owned and directed by any one man. He remained at the head of affairs for over sixty years, a period in which the industrial history of England was completely rewritten. As has been noted, Masham found too late that his wool-comber had been anticipated by Cartwright. But he venerated the memory of the parson-inventor, and nobly perpetuated his memory by the erection, at a cost of £48,000, of a fine building, the Cartwright Hall, at Bradford. Masham was honoured in his own lifetime by the erection of a statue of himself, subscribed for by representatives of the woollen trade in recognition of his genius as an inventor, and of the benefits that he had conferred on the industry. Such a distinction had never before been gained by an inventor within his lifetime. Lord Masham died at Swinton Park on February 2, 1906.

MARIA MONTESSORI
Advocate of Self-Education Through the Senses

Dr. Maria Montessori, the founder of the latest system for educating the very young, was the first woman to take the degree of doctor of medicine at the University of Rome. At the time when she took the degree she was acting as an assistant doctor at the psychiatrical clinic of her university. Dr. Montessori's interest in education began with the treatment of the feeble-minded, a problem to which she devoted years of special study. Her attention was arrested by Séguin's book "Idiotcy and its Treatment by the Physiological Method," and after translating the work into Italian she

went to Paris and investigated the method in use there at the Bicêtre. Returning to Italy, she lectured in Turin and Rome on the education of defectives, and in 1898 was appointed the directrice of a school established to carry out her ideas—the Scuola Ortofrenica, or mind-straightening school. The results of her system were most remarkable. The progress of the children, all very dull and backward, was such that it admittedly made in some respects a favourable comparison with the progress of even bright scholars in the ordinary schools.

Dr. Montessori was herself so impressed that she resolved to concentrate herself afresh on the development of her system, and to that end she returned to the University of Rome for seven years as a student of psychology in special relation to educational methods. At the close of this period she was prepared to apply her own system to the average child. In furtherance of this plan, in 1907 and 1908 four infant-schools were established in Rome for the education of the children living in certain blocks of tenement houses that had been erected as part of an approved building scheme. The age of the children admitted to these "Case dei Bambini," or "Children's Houses," was from three to seven, and the education free.

Here the system achieved such a success as an experiment among the children of the poor that it was adopted for middle-class districts, and it has spread to various European countries, and has been welcomed specially, as all educational experiments are, in the United States. In Southern Switzerland it has become so popular that more than seventy schools have been established in the Canton Ticino alone. A special report on the system as it is at work in Rome has been presented to the English Board of Education by Mr. E. G. A. Holmes, the retired chief-inspector of English schools; and wherever teachers congregate the method described in Dr. Montessori's book, "Il Metodo della Pedagogia Scientifica," translated into English by Annie E. George, under the title "The Montessori Method," is keenly discussed and criticised.

The principle underlying the Montessori method is that of self-education. The child is all the while finding out things for itself. This it does in play, but play that is skilfully directed, the objects with which the play is carried on being made and chosen for educative purposes which the child does not realise. There are no classes, no set lessons, but each child pleases itself. While doing so, however, it is unconsciously, and without strain or effort, learning; and at last—and, indeed, in a very short time—its play has resulted in it being able to write, to read, and to understand simple arithmetic. Its reward is in a sense of discovery and mastery, through its own investigations, the teacher giving each child, individually, hints that help.

The method is by a gradual training of the senses. First, the sense of touch is developed. This sense in the child is keen and easily improved. Roughness and smoothness are first taught by passing the fingers lightly over rough and smooth objects carefully chosen. The child is led to distinguish, when blindfolded, textures, and differences in weight and size—a game that excites general interest. The names of the things are pronounced as they are learned by touch. Next *form* is taught, touch and sight co-operating. In this way the shapes of the letters are learned. Colours are next distinguished and graded. Hearing is also carefully trained. The deft use of the fingers follows, as in tying and untying bows, fastening and unfastening buttons.

Colouring geometrical forms follows, and the pencilling of outlines—the prepared apparatus making success easy. In this way writing comes with remarkable quickness. In six weeks a child of four can be taught to write, and an ordinary child of five in a month. In three months the child will write a good hand. The sounds of the letters and their combinations are learned, and reading follows naturally—in the case of phonetic Italian in a few weeks sometimes, in a few months almost invariably, while the child has only been playing an interesting game.

By similar apparatus the simple numbers and proportions in arithmetic are learned. Lessons are brief, and each child can change what it is doing whenever it wishes to change. Liberty is the basis of discipline—self-discipline—in the "Children's Houses." There is no enforced discipline. Spontaneous activity in the child is respected, used, and never suppressed, unless it involves interference with the liberty of others doing what they please. Dr. Montessori regards self-activity as the basis of discipline. The child not only acquires new capacities by doing, but also attains the necessary self-control and discipline.

That the method is successful in the case of defectives, and with very young children whose mental powers are undeveloped, has been abundantly proved where the supervision has been skilful and the use of the graduated apparatus fully understood, but

less success seems to have been secured when the children come from middle-class homes, are more self-conscious and less easily amused; and further, it is not at all clear how far the method is applicable to children beyond their earlier years who need a wider education. The system is founded on Séguin's experiments. To a considerable extent it follows the plans elaborated by Froebel and his successors. It must not be forgotten that individual acquisition has been allowed free play in many of the best modern schools before Madame Montessori. Still, she has done education excellent service by the freshness she has imparted to child-study, and she takes an honourable place in the true succession of educational pioneers.

JOHN NAPIER

Who Shortened Arithmetic by Inventing Logarithms

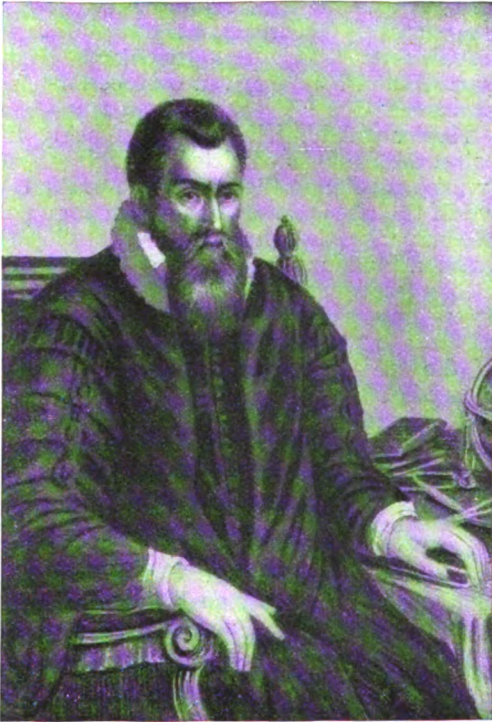
John Napier of Merchiston, the inventor of logarithms, was born at Merchiston Castle, near Edinburgh, in 1550, before his father had completed his sixteenth year. His father, Sir Archibald Napier, was born in 1534, was married in 1549, and became the father of the future mathematician in the following year. Napier matriculated at St. Andrews at thirteen, an evidence of intellectual precocity excelled in our own age by Lord Kelvin. He afterwards travelled in Europe, and then for a number of years was engaged with the political and religious strife wherein his country in general and members of his own family in particular were involved. But his personal inclinations were all in the direction of mathematical and astronomical study; and so anxious was he to secure peace that he would occasionally desire the owner of a neighbouring mill to stop the clacking of his machinery while he worked out some chain of calculations. Astronomy had been reborn, thanks to the labours of Copernicus and Brahe, and was now constantly receiving new light from the discoveries of Kepler and Galileo. But the labour of astronomers was almost intolerably laborious, owing to the difficulty with which their calculations were conducted.

Napier, who felt the need for a simpler method, devoted himself for years to the production of a shorter and easier method. The outcome was his publication, in 1614, of his table of logarithms, a word of Greek etymology signifying the ratios of numbers. The invention of this system was an inestimable boon to mathematicians and astronomers, and to all who have to make calculations for navigation, land surveying, and indeed every pursuit, scientific and industrial, involving a considerable use of arithmetic. It was received with enthusiasm throughout Europe, and three years later Kepler testified his appreciation by dedicating his "Ephemerides" to Napier.

One of the first to welcome and expound the new discovery in England was Henry Briggs, the learned professor of geometry in Gresham College. He discovered a way of further simplifying the table, and posted to Edinburgh to lay it before Napier. In his writings Briggs is careful to show that Napier had already anticipated him, but had not had the time or strength after his long labours to work out the necessary calculations. Briggs undertook the task himself, and his name will ever be honourably associated with the discovery.

Napier was himself by way of being an astrologer, and committed himself to a treatise predicting the end of the world towards the close of the seventeenth century. We may take, then, from another astrologer, Lilly, a human note which tells us of the meeting between Napier and Briggs. It is interesting as showing how the few scholars of the age regarded each other in that day of the unlearned many. Napier had been advised of Briggs's impending arrival, and waited long for him at his house. "'Ah, John,' said Marchiston (Napier), 'Mr. Briggs will not now come.' At the very instant one knocks at the gate; John Marr hastened down, and it proved Mr. Briggs, to his great contentment. He brings Mr. Briggs up into my lord's chamber, where almost one quarter of an hour was spent, each beholding other, almost with admiration, before one word was spoken. At last Mr. Briggs began. 'My lord, I have undertaken this long journey purposely to see your person, and to know by what engine of wit or ingenuity you came first to think of this most excellent help into astronomy, namely, logarithms; but, my lord, being by you found out, I wonder nobody else found it out before you, when now known it is so easy.'"

The famous calculating apparatus called Napier's Bones was announced three years after the logarithms. Much of Napier's mathematical writings remained unpublished until long after his death. By the generality of men of his generation he was not understood, being regarded as a wizard, whose familiar was supposed to be a certain black cat. He was worse than a wizard to the Roman Catholics of his day, against whom his "Plaine Discouery of the

Whole Reuelation of Saint John" was directed. It was addressed to James VI., and told him right plainly that he should begin reform "at his own house, family, and Court," a step the necessity for which he drove home with considerable intrepidity. But Napier not only wrote against Catholics —he prepared to arm his country against them. His inventions for this purpose are mentioned in a paper written to Anthony Bacon, brother of Francis Bacon, entitled "Secret Inventions, Profitable and Necessary in These Days for the Defence of this Island and Withstanding of Strangers —Enemies to God's Religion and Truth."

JOHN NAPIER

Of these the first is stated to be "A burning mirror for burning ships by the sun's beams," of which the author says he is able to give proof and perfect demonstration. The second is "A mirror for producing the same effect by the beams of a material fire." The third is "A piece of artillery contrived so as to send forth its shot in all directions, in such a manner as to destroy everything in its neighbourhood, or cut down the masts and tackle of an entire fleet at once." The fourth is a "round chariot in metal," constructed so as both to secure the complete safety of those within it, and, moving about in all directions, to break the enemy's array "by continuous charges and shot of the arquebuse through small holes." The list of inventions concludes with "devices for sailing under water, and other devices and stratagems for harassing of the enemies, which by the grace of God and work of expert craftsmen I hope to perform."

Napier's inventions were aimed more particularly at the Spaniard, but word was passed about that by means of his perambulating machine-gun he could slay thirty thousand Turks at a single blow! A cynic of our own time has said that if by pressing a button in London we could kill a mandarin in Pekin, everybody would be pressing electric buttons for the mere excitement of the thing; and in Napier's day every man who heard of it wanted to have his own private battue of Turks. Sir Thomas Urquhart declared that Napier, provoked by a wager, gave a demonstration with his machine upon a large plain in Scotland, "to the destruction of a great many head of cattle and flocks of sheep, whereof some were distant from other half a mile on all sides, and some a whole mile." Urquhart's pamphlet has often been quoted, but we may still entertain a doubt as to the evidence concerning the sensational scene said to have been witnessed upon that unnamed plain.

Urquhart tells that upon his deathbed Napier was besought by an old friend to make known the secret of his lethal invention. Napier replied: "That for the ruin and overthrow of man there were too many devices already framed, which, if he could make fewer, he would with all his might endeavour to do, and that, therefore, seeing the malice and rancour rooted in the heart of mankind, will not suffer them to diminish the number of them, by any conceit of his they should never be increased." Napier, who was among the first of scientific agriculturists, and a pioneer of artificial fertilisers of the soil, died at Merchiston on April 4, 1617. His eldest son was raised to the Peerage as Lord Napier. The philosopher is also spoken of as Lord Napier, but he was only a Scottish laird, or, as would be said in England, lord of the manor.

FLORENCE NIGHTINGALE

The Pioneer of Scientific Nursing

Florence Nightingale, heroine of the Crimean War, and pre-eminently distinguished as the reformer of hospital administration and the initiator of the scientific nursing movement, was born at Florence,

May 15, 1820. She was named after her birthplace, but her early years were mostly spent at Lea Hurst, in Derbyshire. While quite a child she gave evidence of her love for nursing—bandaging her dolls, caring for dumb animals, and ministering to the sick and sorrowful. Her girlish aspirations carried her onward into the service of humanity. With brilliant attainments, and admirably qualified to shine in society, she chose to devote herself to the alleviation of suffering. Keeping this end in view, she visited and examined the civil and military hospitals at home and abroad. In 1851 Miss Nightingale went through a strict course of training as a nurse in the institute of Protestant deaconesses at Kaiserswerth, on the Rhine. Afterwards she completed her studies by a careful observation of the methods of nursing and management pursued in the hospitals of Paris. At this period nursing was practised in a very haphazard fashion. Mrs. Fry had, however, established the institution of Nursing Sisters in London (1840), and when Miss Nightingale returned to England she undertook the thorough reorganisation of the Sanatorium for Governesses in Harley Street.

In 1854 arose the great national emergency in which her practical skill was put to a supreme test. War was declared with Russia in the spring, but, owing to the flagrantly defective organisation of the British Army in the commissariat department, English soldiers underwent indescribable hardships. There were no ambulance-waggons, the sick and wounded were carried by sailors in hammocks or in ambulances borrowed from the French, and, to make matters still worse, the huge barrack hospital at Scutari was in a deplorable condition. In this crisis Miss Nightingale nobly offered her services to the Government, and her letter happened to cross that in which Lord Herbert, the Secretary for War, had invited her to proceed to the Crimea. On October 24 (the day before the battle of Balaclava) she departed with more than thirty nurses, and reached Scutari on the eve of Inkerman.

She found the wards overcrowded with patients, while hundreds of wounded were on their way. Miss Nightingale's work during that terrible winter made an ineffaceable impression on the imagination of the English race. Her self-devotion was extraordinary; she would stand for twenty hours at a stretch to ensure that the wounded were properly cared for; and when at night, with lamp in hand, she made her round, the grateful soldiers would kiss her shadow as she passed their beds.

FLORENCE NIGHTINGALE NURSING THE WOUNDED AT SCUTARI DURING THE CRIMEAN WAR

Very soon 10,000 sick men in the hospitals on the Bosphorus were under Miss Nightingale's gentle and capable control; and the effect of her scientific administration was quickly seen in the fall of the death-rate. This had stood at the appalling figure of 42 per cent. in February, 1855, but about the middle of the year it had diminished to 2 per cent. Part of her time was occupied in personally organising the nursing arrangements at the Crimean camp, and while so engaged she herself was

prostrated with fever. Still undaunted, she refused to quit her post, and after her recovery remained at Scutari until Turkey was evacuated by the British, in July, 1856. Her splendid self-sacrifice had won her the reverence and affection of the army, and the admiration and gratitude of the nation.

On landing in England she quietly avoided the honour of a great popular reception awaiting her in London, and escaped to her country home, broken in health, but, happily for the cause of sanitary reform, with a long life of service before her.

The sum of £50,000 was raised as a national gift, and with this Miss Nightingale founded the Nightingale Home for training a superior class of nurses at St. Thomas's

FLORENCE NIGHTINGALE IN 1854

and King's College Hospitals. In 1857 she supplied "the Commissioners appointed to inquire into the regulations affecting the sanitary condition of the British Army" with extremely valuable evidence gathered from her Crimean experience, and emphasised the lessons deducible from the colossal experiment in sanitation which the war had necessitated.

In 1858 she published her "Notes on Nursing," and in 1859 the "Notes on Hospitals." Both books are clearly and suggestively written, and, containing a wealth of practical details, they have proved of immense value to women students, as well as to men professionally concerned with the planning and construction of hospitals. She also wrote "Notes on Lying-In Institutions," and in 1873 "Life or Death in India."

The benevolent mission which Miss Nightingale so courageously fulfilled in Scutari was the beginning of a new era in hospital administration. Her contribution to human welfare was not limited to mitigating the evils of war by the impetus she gave to army reforms bearing on the treatment of the sick and wounded. Her own unselfish example stimulated ladies of her class to study the science of nursing, and to apply it to the needs of civil life. It was high time that the type of nurse which existed fifty years ago should disappear. The whole character of nursing was revolutionised. A nurse, according to Miss Nightingale, should receive careful training, should be intelligent, skilful, and trustworthy, and have a good grip of the principles of hygiene. The most striking outcome of her work was the institution of the Red Cross Society. But not less impressive is the fact that every parish, district, and workhouse has now its nurse, or staff of nurses, acting under the instruction of the local physician, or even competent to act alone in cases of minor importance. This is very largely traceable to Miss Nightingale's earnest efforts.

The freedom of the City of London was given to her in 1908. She had already received the rare honour of the Order of Merit in 1907. She died on August 13, 1910, at the age of ninety. The story of the world from first to last does not tell of a more womanly woman.

ROBERT OWEN

The First Opponent of Child Labour

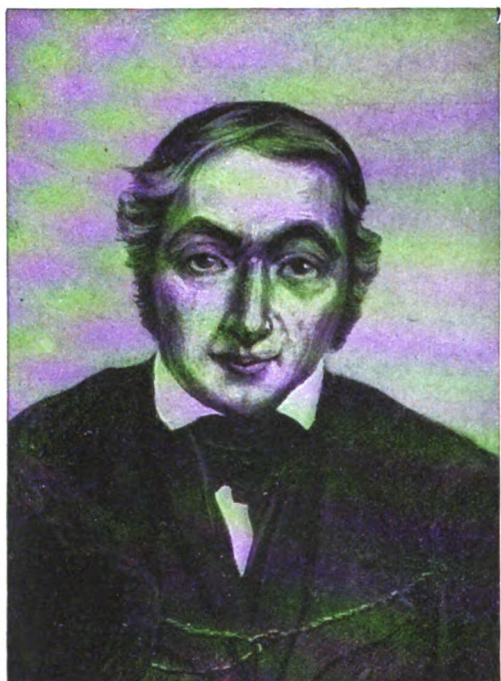
Robert Owen, social reformer, was born at Newtown, Montgomeryshire, on May 14, 1771, the son of a saddler. A bright, intelligent boy, he quickly learned all that his master had to teach him, and upon his own showing was usher of his school at seven. Before he had completed his tenth year his omnivorous reading had convinced him that there was something fundamentally wrong in all religions. He left school in 1780, and after an interesting and highly creditable youth, of varying vicissitudes, became manager to a Mr. Drinkwater, cotton manufacturer, of Manchester. Owen quickly mastered the details of the business, increased its scope, and exercised a powerful influence over the workmen. He was only twenty years of age at this

time, yet he had already come to the conclusion that human character results from antecedents and surroundings, and argued that, given fair conditions and means of education, men would naturally become moral and useful citizens. Charity was the keynote of his relations with his workmen, and certainly he got wonderful results from his policy.

Owen was an admirable business man as well as a philanthropist; and when a change was made in the Drinkwater business, in which he had already been given a proprietary interest, he established, with other partners, a business of his own. Among the important things achieved at about this period of his life were the introduction into England of American cotton, and the removal of the tax upon this indispensable raw material. During his travels Owen had met Miss Anne Caroline Dale, daughter of that David Dale who was the veritable Scotch "razor" fashioned by Arkwright to shave the truculent cotton manufacturers of Manchester. Dale had by this time waxed prosperous, and had instituted at his New Lanark mills perhaps the first attempt at an industrial model village in Great Britain. Dale was a town-planner before Owen.

Two years before Owen became his son-in-law, Dale had his "little kingdom" of neat, well-built houses, forming broad, regular, and cleanly streets. "Five hundred children are entirely fed, clothed, and instructed at the expense of the venerable philanthropist," wrote a visitor at the time. "The rest of the children live with their parents, in comfortable and neat habitations in the town, and receive weekly wages for the labour. . . . It is a truth that out of nearly three thousand children working in these mills, during a period of twelve years, from 1785 to 1797, only fourteen have died, and not one hath suffered criminal punishment. The lesser children, that are not old enough to work, are instructed in the daytime; the elder children learn in the evening, when the daily labour is concluded. Proper masters and mistresses are employed to teach the boys and girls. The boys learn to read and write and cast accounts; the girls, in addition to these, are taught to work at the needle." Therefore, without in any way detracting from the work achieved by Owen, we see here where, possibly, the germ of his ideas as to the education for the young was gained, and it should make us examine with care the statement that schools for infants originated with him. The objectionable features of Dale's "little kingdom" have yet to be considered by us.

ROBERT OWEN'S IDEAL SETTLEMENT

Owen was afraid to ask Dale, whom he had never seen, for the hand of his daughter, so he adopted a curious method. Instead of the daughter, he asked the old man for his business! He proposed to buy him out for £60,000, payable in twelve annual instalments. He married the daughter, and, in a way, the business, and began his work of reform. The "five hundred children" mentioned in the statement quoted were pauper children, taken from the workhouses and other public institutions, and, despite the care of their master, they were greatly overworked, and could not have been fit to receive instruction at night. Moreover, the adult workers, according to Owen, were

ROBERT OWEN

drunken and riotous. It was not difficult to introduce improvements on what was, considering the state of public opinion at the time, a really considerable advance upon the conditions existing elsewhere in the bad old days. Owen stopped the import of paupers; he improved the circumstances of the adults, both in regard to their life in the mill and in the home; started a co-operative store at which they could buy good food and other articles cheaply; inculcated sobriety and honesty, and, when cotton supplies temporarily ceased, paid the wages of all his hands for seven months, at a cost of as many thousand pounds. His revolutionary schemes brought more than one change of partnership, but finally he got a free hand for a time, and in that period instituted admirable schools, which took infants as soon as they could walk, and kept them there up to the age of twelve, when, and not before, they were permitted to enter the mill. His scheme of education for children should be studied today. There is no plan of 1913 more modern. Advocates of education by persuasion and pleasant, easy methods have within the present year been called upon to defend their plan against critics of their new and revolutionary schemes. It was all in the Owen curriculum of a century ago. His schoolmaster for infants could scarcely read or write, but he had infinite patience and fondness for children; and when Brougham and other noblemen started in London a copy of the New Lanark infants' school, they borrowed Owen's unlettered pedagogue for their school at Westminster!

Owen in 1812 published his notable "New View of Human Society," expounding his theories of character and education; and his mills, with their school and settlement, became a place of pilgrimage for social reformers. Princes and peers, exalted ecclesiastics, reformers of half a dozen nations, and streams of lesser philanthropists made the journey to his place, and he was quite one of the most considerable men in Europe, welcomed and honoured in every country to which he travelled. The outstanding feature of this part of his life was Owen's attack upon the factory system in regard to child labour. Factories were unknown until Arkwright's day; the system had become widespread by the time Owen reached Scotland. The youngest children were hustled into steaming, unhealthy, ill-ventilated mills, and kept there as long as their masters chose to detain them. A new horror had come into the child-life of Britain.

Owen urged upon Peel that no child should be admitted into a factory until ten years of age; that no child under the age of eighteen should be permitted to work more than ten and a half hours a day, and that instruction for children engaged in mills should be compulsory. The demands seem small as one reads, but, even so, they were whittled away by Peel under pressure from the manufacturers, until only the bald and unconvincing Factory Act of 1819 resulted. Still, that was an achievement. It recognised as a principle for the first time that the State really owed a duty as guardian of the least mighty of its subjects; it for the first time denied to grinding manufacturers

and greedy parents the right slowly to work a babe to death.

Thereafter Owen, while he effected a fine work in the promotion of co-operation, was engaged in fruitless and visionary efforts to found ideal communistic colonies. He sought to effect, with promiscuously gathered assemblages of all sorts and conditions of men, the purpose which he had previously taught could only be gained by the training of the masses from childhood to morality, sobriety, and all the duties of citizenship. He tried his scheme in the United States, in Mexico, in England, in Ireland, and it was in the end defeated, as from the very nature of the case was bound to happen. His uncompromising hostility to all orthodox religion did not help to make his path more smooth, but, strange to say, he ended by turning spiritualist. He died at his birthplace, Newtown, on November 17, 1858.

BERNARD PALISSY

The Heroic Potter

Bernard Palissy, the prince of potters, was born at either Saintes or Agen, in or about the year 1510, and was apprenticed to a glass-painter. Afterwards he became, as was the custom for men of his type, a wandering craftsman. His travels led him through the Netherlands and part of Germany, as well as over the greater part of France, and during this time he acquired a knowledge of land-surveying, which was to prove serviceable to him in later years. A faithful student of Nature, he observed bird and beast and flower, with results which will presently be shown. He settled down at Saintes, and there married, when some twenty-eight years of age. He earned a livelihood by painting on glass, by land-surveying, and portrait-painting. Then there came into his life an all-absorbing passion, kindled by the sight of an enamelled cup of exquisite workmanship, embellished by the loveliest of translucent enamels. The story of the disappearance from European art of enamel-work is detailed in the life of Böttger. Now, to what school of art pottery this special piece belonged, whether to that of Luca della Robba or to the Chinese school, cannot be determined, but expert opinion inclines to the Chinese.

Palissy, who knew nothing of the craft save such rough and ready experience as he had gained of peasant pottery, determined to make an enamel of his own. He tried innumerable experiments, as he was bound to do, for he had no books upon the subject; nothing was known, and he was unable to leave his family and travel in quest of such knowledge as might be expected to exist. He could only conduct his own unassisted experiments, trying combination after combination of materials and chemicals, breaking up pottery and mixing the fragments with his compounds, and burning them in the furnace he had made. Failure succeeded to failure, yet each fired him with firmer determination to succeed. Pots and fuel, fuel and pots—these were his constant demand, and his purchases and the time given to the work brought him to abject poverty. With a little family growing up about her, his wife not unnaturally resented what seemed to her a visionary quest, the certain issue of which appeared starvation for herself and her children. But Palissy kept on, and at the end of two years of frenzied labour produced, from a kiln of 300 pots, one which bore a white glaze, which he described as singularly beautiful.

He had, in the meantime, been compelled to carry his wares to a tile-furnace four miles away. Now that he seemed on the track, he set out to build himself a new furnace at his own home of the type in which he had gained his one success. He built his furnace single-handed, carrying the bricks upon his back from the brickfield, and laying them without assistance. He procured a large supply of fuel, started his fire, and waited for his enamel to melt and diffuse itself over his pots. It refused to yield. All through the night he stoked his furnace, and all next day, never leaving his fire for more than a moment or two; all the next night, and so on for six days and nights—all for nothing. Then he tried a new flux, and he staked his all upon the trial. He reached the end of his fuel, and burnt the garden palisadings. Still the enamel had not yielded; he burnt the household furniture, and after that the very shelves. And while his wife and family ran wailing through the town, crying that poor Palissy had gone mad, and was breaking up the home for firewood, the enamel melted, and the common brown household pots, that went in unlovely, were taken out of the furnace coated with a beautiful enamel.

Feeling that success was assured, he engaged a potter to work for him, but was so poor that he could only give the man his clothes in lieu of payment, while he begged food and lodging for himself of a friendly innkeeper. When at last the first trial came, flints which he had employed when building his furnace cracked and burst, and, though the enamel proved right, it was

covered with débris from the flints. Six months' hard work had gone to this failure, but Palissy would not sell his wares; he smashed them because they were imperfect; and amid the mockeries of his fellow-townsmen and the unending reproaches of his family he continued at his work.

His courage and hope were incomparable. "Sometimes," his autobiography tells us, "when visitors called, I entertained them with pleasantry, while I was really sad at heart. . . . Worst of all the sufferings I had to endure were the mockeries and persecutions of my own household, who were so unreasonable as to expect me to execute work without the means of doing so.

BERNARD PALISSY

For years my furnaces were without any covering or protection, and while attending them I have been for nights at the mercy of the wind and rain. . . . Sometimes the tempest would beat so furiously against the furnaces that I was compelled to leave them, and seek shelter within doors. Drenched by rain, and in no better plight than if I had been dragged through mire, I have gone to lie down at midnight or at day-break, stumbling into the house without a light, and reeling from one side to another as if I had been drunken, but really weary with watching, and filled with sorrow at the loss of my labour after such long toiling. But, alas! my home proved no refuge; for, drenched and besmeared as I was, I found in my chamber a second persecution worse than the first, which makes me even now marvel that I was not utterly consumed by my many sorrows."

For sixteen years these unparalleled efforts lasted, and at last success was achieved. But Fate was not tired of buffeting the valiant man. Just as success and fortune came to him, religious persecution claimed him among its victims. He was an out-spoken Protestant, and as such he was in 1562 thrown into prison at Bordeaux, and condemned to be burnt at the stake. He was saved by the Constable of Montmorency, who desired that the enamelled tiling of his new palace should be completed. By the Constable's influence Palissy was appointed Inventor of Rustic Pottery to the King and Constable, and he moved to Paris, where he established himself on the site of what afterwards became the Tuileries, so-called from its being the place of the tile-burners.

Palissy's troubles now seemed at an end. Assisted by his sons, he carried on his pottery-work under the best auspices, and had leisure for other pursuits. He wrote on pottery, on natural history, on the cause of earthquakes, on fortification, on water-supply. His close observation of Nature enabled him faithfully and beautifully to reproduce not only existing forms but extinct forms of life. "It was reserved for a potter without either Latin or Greek," wrote Fontenelle, "to have the hardihood, in the latter part of the sixteenth century, to declare in Paris, and in the face of all the doctors, that the fossil shells were real shells, deposited by the sea, once upon a time, in the places where they were found, and that animals had given to the figured stones all their different figures, and boldly to defy the school of Aristotle to attack his proofs.'

We all know today that Paris and the Sphinx and the Great Pyramid are built of exactly the same material. Paris is founded on extinct nummulites, and the two landmarks of Egypt are composed of rock consisting entirely of fossil shells of the same form of life. But to declare such a thing in Palissy's day was the blackest heresy.

Not for this statement alone, but for his whole conduct as a fearless Protestant, he was cast into the Bastille, and threatened with death unless he recanted. Henry III. visited him in his cell to say, "We have put up with your adhering to your religion

amidst fires and massacres; now I am so pressed by the Guise party, as well as by my own people, that I am constrained to leave you in the hands of your enemies, and to-morrow you will be burnt unless you are converted." But the steadfast old hero replied, "Sire, I am ready to give my life for the glory of God. You have said many times that you have pity on me; now I have pity on you, who have pronounced the words 'I am constrained!' It is not spoken like a king, sire; it is what you, and those who constrain you, the Guisards and all your people, can never effect upon me, for I know how to die!" Palissy was spared the stake, but he died in his dungeon in 1589, one of the finest types of noble, intellectual manhood of his own or any other era.

JOHN HENRY PESTALOZZI

A Kindler of Enthusiasm for Education

John Henry Pestalozzi, one of the most distinguished of educational reformers, was born at Zurich, Switzerland, January 12, 1745. His father, an able physician, died when the boy was five years old. Brought up by an unselfish mother, he grew good-natured, dreamy, and sympathetic, but reserved, and incapable of guarding his own interests. At school his guilelessness exposed him to the banter of his companions, who nicknamed him "Harry Oddity of Follyville" as a mark of their boyish esteem and goodwill. He was not precocious, nor was he dull; but he was never at any time proficient in reading, writing, or keeping accounts. From the elementary school he proceeded to the University of Zurich, where he made some progress in theology. As a student he was one of a little band of reformers smitten with a passion for the ideas of Rousseau, and it was in a college magazine that Pestalozzi first disclosed his views on education. "I would," he says, "that someone would draw up in a simple manner a few principles of education intelligible to everybody." And he would have such a pamphlet distributed "to fathers and mothers, so that they might bring up their children in a rational and Christian manner."

Pestalozzi was already deeply interested in the problems created by the inequalities of society; the privileges of the rich jarred harshly on his sensitive spirit as he contemplated the distress, ignorance, and universal want of his countrymen. Of himself and a knot of fellow-students he says, "We decided to live for nothing but independence, well-doing, and sacrifice for love of country;" and he avows his chief purpose in life was to secure a happier fate for the poor of his native land, by improving and simplifying their educational privileges. His intention of becoming a minister was disturbed by the failure of his first sermon; so, with the same resolution to turn his education to the advantage of others worse situated than himself, he began the study of law. However, it ended in the burning of his legal manuscripts, and his decision to become a farmer.

With philanthropy as his guiding motive, Pestalozzi then borrowed money, bought a farm of a hundred acres, and made his object the cultivation of madder, and the instruction of the peasantry in better and more profitable methods. In the midst of this new venture he married (1769) Anna Schulthess, a young lady of considerable means, and seven years his senior. One of his love-letters is a model of candour and self-revelation. He confesses his utter indifference to polite conventionalisms; his improvidence, his inability to grapple with emergencies, and his patriotism, which, if called upon, would urge him to risk all to alleviate the misery of his fellow-creatures. But Fräulein Schulthess was undaunted, and shared his struggles for over fifty years. In five years his farming enterprise had to be abandoned. He was "an agricultural visionary," and admits that his failure arose from his pronounced incapacity for every kind of undertaking which requires practical ability. Here, again, considerations of self were submerged in his zeal for humanity. In this spirit of self-abnegation lay his lasting influence as a teacher.

For Pestalozzi was determined to make a great educational experiment. He converted his large farmhouse at Neuhof into a school (1774). He began with twenty poor children. He fed, clothed, and lodged them in return for such work in the fields or at the distaff as he might require of them. The children often learned their lessons while they worked with their hands, for Pestalozzi used conversation on common objects as a primary means of conveying information. In a few months, love, gentleness, and care had transformed these poor little creatures into hearty, intelligent beings. It was the first "industrial school."

News of his success quickly spread. Pestalozzi claimed to have proved that health lost through idleness or mendicity can be repaired by systematic work; that the most depraved are touched by kindness;

and that the abjectly poor brought up in private establishments where manual and mental instruction are suitably blended can be raised to a higher and happier plane of life. Sanguine as ever, he enlarged his undertaking, but his almost total incapacity for administration plunged him into bankruptcy. In 1780 his wife's fortune had disappeared, and for eighteen years he was destitute.

He took to authorship, and his popular book "Leonard and Gertrude" was published in 1781. It is also his best book; and from its pages and those of "How Gertrude Teaches Her Children" (1801) may be gleaned the leading principles upon which Pestalozzi founded his system. He believed in the magic of the teacher's personality. His most important aim was the concurrent and harmonious development of all the faculties that a child possesses. The child must be encouraged to acquire knowledge through the energetic exercise of its senses.

Instruction should be founded on observation, especially with infants. Object-lessons are of the utmost value. A child must be put into actual contact with concrete things, and infer their nature from handling and examining them. There are three classes of object-lessons, applicable to form, number, and speech. Mr. Quick, in explaining Pestalozzi's aim, says object-lessons are intended (*a*) "to enlarge gradually the sphere of the child's intuition; (*b*) to impress upon him those perceptions of which he had become conscious with certainty, clearness, and precision; (*c*) imparting to him a comprehensive knowledge of language for the expression of whatever had become or was becoming an object of his consciousness." The higher needs of the intellect were not to be overlooked; mathematics, history, and music should receive due attention. But the most potential principle that Pestalozzi brought into the schoolroom was love; and his message to the world was that education was the richest of all gifts, whether it be to rich or poor.

When fifty-three years old, Pestalozzi left Neuhof, and resumed school work at Stanz. From thence he went to Burgdorf, and finally to Yverdon, on Lake Neuchâtel (1804). Yverdon has been named the Mecca of Pestalozzianism. There the educational career of the celebrated teacher came to a close in 1825. He died two years afterwards, at Brugg (Aargau), on February 17, 1827, at the age of eighty-one.

SIR ISAAC PITMAN
The Populariser of Phonography

Sir Isaac Pitman, the man who brought to predominance a single system of shorthand in this country, and throughout the world, until it is written with a considerable degree of expertness by probably half a million people, was born at Trowbridge on January 4, 1813. His father was engaged in the West of England woollen trade, first as an overseer in a factory, and afterwards as a manufacturer. The son began life as a clerk, but became a teacher, first in Lincolnshire and later in Bath. He continued in school work until 1843, though increasingly his time was taken up in popularising his system of shorthand, which had been introduced to the public in 1837 in a book entitled "Stenographic Sound-hand." A second edition came out in 1840. Two years later Pitman started "The Phonetic Journal," which still continues its useful career. From 1843 onwards the inspirer of the movement devoted all his energies to it, and established himself in London in 1845. The jubilee of the system was commemorated in 1887, and in 1894 its founder was knighted.

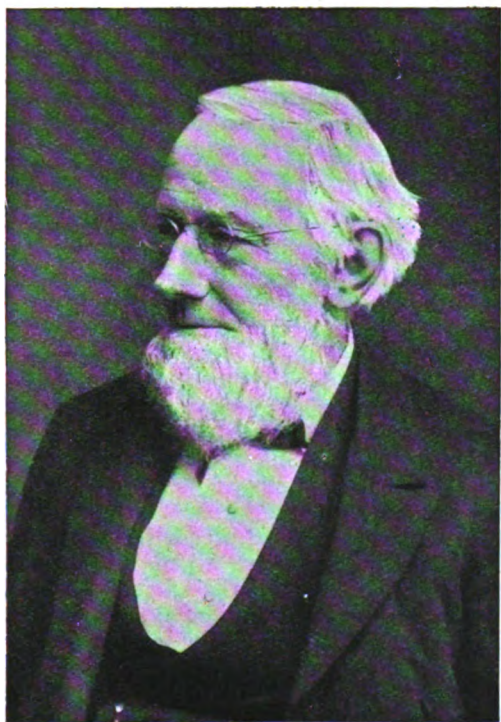
The number of books for the teaching of phonography issued by the Pitman firm before the death of its head on January 22, 1897, was counted not in thousands but in millions. Although, of course, there are many systems of shorthand, several of which can be used with confidence for reporting purposes, and in a small proportion of cases are so used, Pitman's system practically commands the field, and that, too, with manifest advantage. It is a decided gain that one system of shorthand should be in general use.

Complaints are sometimes heard that the system is difficult, and, unless freely sprinkled with vowel-sounds, is not legible, but there is no easy way to shorthand. Under no circumstances can the hand move as quickly as the tongue can speak without long and careful training, and pretences to produce a cheap and easy system have always been delusive. The Pitman system, when properly known, and when practised till the writing becomes spontaneous and almost instinctive, is not only effective, but it is beautiful in its flowing outlines.

When one recollects how much of the work of the world, in business offices, in law courts, throughout the whole realm of newspaper enterprise, is being done daily, with enormous expedition, through the use of shorthand, one realises that the man

who organised the means for this work, and focussed it into efficiency, is indeed one of the most practical of all pioneers. The principle of the Pitman system is that the characters shall represent not spelling but sounds, and it has been applied successfully to almost every largely used language in the world. A very substantial part of readable English literature may be obtained printed in the Pitman script.

JOHN POUNDS
The Founder of Ragged Schools

John Pounds, the crippled shoemaker who founded Ragged Schools, was born at Portsmouth on June 17, 1766. He had in

SIR ISAAC PITMAN

him the makings of a giant, for at fifteen years of age he was six feet in height and finely proportioned. But while working at the docks with his father he fell into a dry-dock, and shattered and dislocated one of his thighs. Today the injury would be swiftly repaired, but it sentenced John Pounds to physical incapacity for the rest of his life. He turned his attention then to cobbling, and was taught the rudiments of his trade by a friendly old bootmaker in that town. It was not until he was getting on towards forty years of age that Pounds set up in business for himself, and posted his sign over a little, weather-boarded tenement in Mary's Street, Portsmouth. He was quite a moderate workman, with a moderate workman's earnings, but his simple requirements enabled him to save a little money, and he felt that he ought to assist his family. He did so by taking into his care the little crippled son of his brother, who was a man of large family.

Lacking the means to buy the necessary "irons" for his nephew's deformed feet, he made a pair himself, and had the gratification eventually of seeing the child's limbs made straight. When the time came for educating his small charge, he thought he would manage better if the child had companionship, so he sought out first one or two and eventually half a dozen poor little waifs and strays whom he picked up in the pitiless streets, and founded his tiny school in the mean workshop in which he toiled. Once embarked upon his mission of mercy, the generous heart of the crippled cobbler yearned for the redemption of other little outcasts; and by degrees the small class, first intended for the education of his own nephew, became a properly organised school in the tiny tenement. He came to have about forty scholars; and when the school overflowed, those who were most trustworthy would be allowed to sit out near the door or even on the pavement. The only difficulty was to catch his pupils in the first instance. The good-hearted cripple would prowl round the docks or other public place and select the most forlorn and desperate-looking little ruffian he could find. The bait would be a hot roasted potato, a never-failing lure; and while the hungry urchin ate his meal he would be beguiled away to the little shoe-mending den, to be enrolled as a scholar and apprenticed to the art and mystery of becoming a reputable citizen. It was wonderful work, carried out by this one disabled, noble-hearted cobbler. Here is a picture of him at work in the midst of his class:

"His humble workshop was about six feet wide and about eighteen feet in depth. In the midst of it he would sit on his stool, with his last or lapstone on his knee, and other implements by his side, going on with his work and attending at the same time to the pursuits of the whole assemblage—some of whom were reading by his side, writing from his dictation, or showing up their sums; others seated round on boxes or forms, on the floor, or on the steps of a small staircase in the rear. Although the master seemed to know where to look for

each, and to maintain a due command over all, yet so small was the room, and so deficient in the usual accommodation of a school, that the scene appeared to the observer from without to be a mere crowd of children's heads and faces."

Quite without experience, he evolved an admirable system of teaching. Reading he taught from old handbills or ancient schoolbooks which he had bought or begged for the purpose. Writing was taught on slates; sums carried his scholars as far as

JOHN POUNDS

compound proportion. The elder boys and girls—of the latter there were twelve—were taught to cook and to mend their own boots and shoes and clothes. He and his young assistants made all the toys, bats, balls, bows and arrows, kites, and shuttlecocks; and when they went on their country excursions, as they frequently did, lame John Pounds was not only guide, philosopher, and friend, but an enthusiastic director of sports and games. He fed them, he clothed them, tricking them out on Sundays in old garments he had collected during the week from people sympathetically disposed towards him and his work. And with his bright birds in their new, or at any rate cleanly, feathers he would lead them proudly off to the little mission hall at which he devoutly worshipped. This work went on year after year, until the noble old cobbler was past his threescore years and ten. Boys that he had snatched from the beginning of a career of crime had in the meantime grown up, had become soldiers, sailors, honest artisans. During lessons some of these, home from the wars or from distant travel, would drop in to see their old mentor. And the honest fellow would weep with joy at the sight of one of his protégés come creditably home to offer him the handshake of gratitude and remembrance.

All the work that Pounds did was free of cost to his bairns. He would have thought himself unspeakably mean to have accepted material requital of his services. His tiny legions of the lost were his joy and pride; and when he could not expend quite enough human kindness upon them, and thought that there was still a dispensable shot in his locker, he would feed and in other ways assist his indigent neighbours in times of hard weather and distress. John Pounds, one of the great little men of the earth died, aged seventy-two, on January 1, 1839. He passed away at his work, for he was embarking upon a prime adventure—he was arranging for a little supply of copy-books for his children, when suddenly the hand of death descended upon him. He breathed his last when his friends raised him from what they first took to be only a swoon. But John Pound's work lives on after him. The story of his career fired the imagination and zeal of many friends of the poor, and the immediate outcome was the formation of the Ragged School Union. And Lord Shaftesbury was not the only man illustrious in our history who has been proud to say, "I am a disciple of John Pounds."

JOSEPH HUBERT PRIESTLEY

A Pioneer in Electric Gardening

Professor Joseph Hubert Priestley, who has conducted some remarkable experiments in a new method of farming, is the son of a headmaster of Tewkesbury Grammar School. He was born on October 5, 1883, and educated at his father's school, and afterwards at University College, Bristol. Here he specialised in the study of botany, and so distinguished himself that at

twenty-two he was appointed Lecturer in Botany at Bristol, and head of the Botanical Department. In 1911 he became Professor of Botany at the University of Leeds. While at Bristol he fitted some greenhouses at Bitton with electrical wires running above the growing plants, and he showed that by applying an electrical current the growth of plants could be stimulated in a curious manner. It is thought that the electrification of a crop checks minute and primitive animals in the soil, which prey upon certain microbes that fertilise and assist growing plants. But it may be that the electricity also stimulates the activity of the plants. In the first case, a steam-jet might prove a quicker and more convenient way of promoting the growth of beneficial microbes. In the second case, it might pay gardeners and farmers to use electricity when this is available at a low cost.

ROBERT HEBERT QUICK

The Historian of Education

Robert Hebert Quick will long hold a place in the world of education as the writer who made the history of education interesting by tracing it along the lives of the great educators. Until he wrote, the subject was dull and unrealised, even by people who were closely engaged in educational work, but he made a swift, clear stream of specialised history to flow along the channel of education. He redeemed a great subject from the casualness which before had seemed to suffice. Quick was born in London, the son of a prosperous merchant, on September 20, 1831, and educated at Harrow (a private tutor's), and Trinity College, Cambridge. On leaving Cambridge he took Holy Orders, and worked in London for some time as a curate with his friend the Rev. J. Llewelyn Davies. Afterwards he held masterships in various schools, including Harrow, became a lecturer on education at Cambridge, and in 1883 was given by his college the living of Sedbergh, Yorkshire, from which he retired in 1887. He died at Cambridge on March 9, 1891. The book by which he will always be known was his "Essays on Educational Reformers," first published in 1868, and enlarged and freely rewritten for a final edition in 1890. For the writing of this book he was partly equipped by a sound knowledge of German. Quick lived to see his survey of educational history in use in many training colleges, and quoted as both interesting and authoritative in every history of education, written either in English, French, or German.

Perhaps the most effective way of seeing how little appreciation there was of the consecutive story of the growth of educational ideas and methods is by examining Quick's own writings on the subject. When he began his survey of educators, past and present, he had to search far and wide for materials; and though he was in love with his subject, and singularly open-minded, so that every form of information was welcomed by him, there were manifest gaps in his plan, and some of the greatest students of education were missed by him. For example, Herbart only appeared in an insignificant note at the bottom of a page. Such omissions were rectified later.

JOSEPH HUBERT PRIESTLEY

It is not too much to say that Quick's enlivening books, more than any other influence, stimulated the writing of histories of education, until now half a dozen such works hold the field, not unworthily, though none of them has the movement, personal interest, and literary lightness of the "Essays on Educational Reformers." Such men as Comenius, Locke, Rousseau, and Pestalozzi were brought into their true relation to the age-long story of educational endeavour by the freshness of their presentation through Quick's pages. Brisk enough to be read by the youngest, and full of human interest, these essays had the power to make teachers feel their work had a new dignity.

A BIRTHPLACE OF NEW KNOWLEDGE

SIR WILLIAM RAMSAY EXPERIMENTING WITH RADIUM IN HIS LABORATORY

CONTINUED FROM 4713 CONTINUED ON 4953

CHEMISTS & PHYSICISTS

GUSTAVE LE BON

The Versatile Doctor who Founded a New Alchemy

Gustave le Bon, one of the most versatile of living men of science, was born at Nogent-le-Retrou, a town some distance to the south-east of Paris. He comes of Breton and Burgundy gentry, but the revolutions in France have left him only an aristocratic tradition. What wealth he has he has himself earned. Like many men of an original turn of mind, he was a very poor scholar in his youth, and even in early manhood he only just managed to pass his examinations for the degree of a doctor of medicine. He attributes this to the fact that the system of French education is designed for the average, unoriginal mind, and that any boy that tries to think out things for himself wanders away from the official groove of knowledge, and so makes a poor show at examinations.

Le Bon began his scientific career in 1879 by researches on the law of variations in human skulls. He then studied Turkish tobacco, which was supposed to be comparatively harmless, because little nicotine was found in it by ordinary methods of analysis. He employed a new method of examining the contents of the smoke instead of analysing the unburnt leaf. He found in the products of combustion prussic acid and a new series of poisonous alkaloids, which went to show that the toxic effects of Turkish tobacco were very much greater than had been thought. But this remarkable essay in chemistry did not determine the career of the young doctor.

Putting all his work aside, he began a new career as a traveller, and, after wandering through Morocco and Egypt, was sent on a Government mission to India, and was the first Frenchman to explore Nepal. A series of brilliant works on the civilisation of the Arabs, the Hindoos, and the early civilisations of the Orient was published by him, together with some books of descriptive biography. But, finely as he handled the knowledge he had won in his travels, it was not until 1895 that he really revealed his genius. In this year all his wide and varied studies of human societies flowered into a great and fundamental idea of the workings of human nature in large groups, which he expounded in his "Psychology of Crowds." This searching and profound inquiry into the soul of the mob is one of the corner-stones of the modern science of social actions and habits.

While he was thus revolutionising an important branch of the social sciences, Le Bon was conducting some extraordinary experiments in chemistry. He found that if a phosphorescent body, such as sulphide of calcium, is exposed for a minute to sunlight, it preserves for eighteen months the power of emitting invisible radiations that can be photographed. He also discovered that nearly all forms of matter, when exposed to sunlight, and then placed in darkness, give out invisible rays which have the property of electrifying the surrounding air. These mysterious rays he termed "black light."

His first paper on the subject appeared in 1896; and when A. H. Becquerel soon afterwards published his researches on the strange radiance emitted by the salts of uranium, Le Bon was able to give the true explanation of this radio-activity. Becquerel thought it was merely a form of light, a kind of phosphorescence. But Le Bon repeated the experiment, and found that the uranium ray was not a form of light, but a wonderful product of the breaking up of atoms and the destruction of matter. His theory was suggested rather than proved by his experiments, but it was afterwards more strongly supported by the discovery made by English chemists that

radium was breaking up into the lighter element of helium, in the act of emitting its strange bundle of rays.

There has been much angry dispute in both France and England as to the part played by Gustave le Bon in working out the modern theory of the breaking up of the elements. He has certainly raised a vast structure of ideas on a small foundation of ascertained fact. On the other hand, his main theory is borne out by later discoveries made by other men, so that he is entitled to rank as a pioneer in the new science of radio-activity. Possibly he is somewhat of a jerry-builder in science, for he is inclined to make magnificent theories out of mere suggestions. For instance, he supposes that all forms of matter are spontaneously decaying into the ether out of which they were originally formed. This is going much too far. In the first place, it is not certain that all forms of matter are of themselves continually breaking up and disappearing. In the second place, it is not absolutely certain that the ether exists. So Le Bon's theory of the evolution of matter out of ether and its dissolution into ether is a somewhat imaginative idea. The famous French doctor is a man with fine qualities of mind, and the defect of those qualities. He is very original, but very speculative. Sometimes he is really in advance of other men of science; sometimes he is a weaver of cobwebs of thought that entangle rather than guide.

JUSTUS VON LIEBIG

Father of the Chemical Industries of Germany

Justus von Liebig, the founder of German industrial chemistry, was born on May 12, 1803, in Darmstadt, where his father kept a small drug and grocery shop. In boyhood, Liebig was a very poor scholar, and after an unsuccessful time at school was apprenticed at sixteen to an apothecary. Unfortunately, he was as bad a hand at pill-making as he was at learning Greek verbs, and, besides, he had a very fiery and impulsive nature. After a struggle, he induced his father to allow him to go to Bonn University to study chemistry. But there was nobody in Germany at that time able to teach modern chemistry in a proper way, and after taking his degree young Liebig went, at nineteen, to Paris, where, with some difficulty, he obtained a place in Gay-Lussac's laboratory. Here he worked for two years, becoming at twenty-one a master of the new science. He engaged in the study of the metallic compounds of fulminic acid, so named on account of the formidable explosive character of its salts. With rare skill and courage, Liebig determined the composition of the dangerous acid, whereupon Gay-Lussac seized him, and danced round the room in the wooden shoes in which he worked. "I must do it!" he exclaimed, to the astonished young German doctor. "It is a habit of mine on the occasion of a new discovery. I can only express my ecstacy in the poetry of motion!"

The fact was, Liebig's first discovery was of surprising range. He was able to show that his terribly explosive fulminic acid was identical in composition with the harmless cyanic acid. All ideas were upset by this proof that the same number of atoms could produce two entirely different substances. It made chemistry a very difficult science. Some of the highest authorities opposed Liebig's view; and had it not been that another young German, Wöhler, attained a similar result about the same time, the strange and puzzling fact would have been long disputed and contemned.

As it was, even the men opposed to it were at last forced to the conclusion that something else counted besides the actual number of atoms in a substance. It was the way in which the atoms were arranged together that made the difference between a dangerous explosive and a harmless acid. Having helped one another against the older school of chemists, and introduced a new and important idea into chemical science, Liebig and Wöhler became fast and loving friends, and for some years they worked together and published their discoveries under their two names. Their splendid friendship is one of the finest things in the history of science.

The two men completed each other. Wöhler was cool, deliberate, and unimpassioned, doubtful of his own ideas, and careful to test every link in his chain of research. Liebig was fiery and impetuous, receiving a new thought with enthusiasm, and letting his imagination play on it; ready to knock down a man who said he was wrong, and then pick him up and kiss him when he found that the man was in the right. Wöhler started many ideas of the partnership in discovery; Liebig developed them, and gave them largeness, range, and importance. Neither man worked so well by himself as he did with his friend.

At twenty-one Liebig was made a sort of assistant professor of chemistry at Giessen; two years later he was appointed ordinary

professor. He was a man with regular features, dark, shady eyebrows, and great, brown, shining eyes—the eyes of a creative poet who used chemical instruments instead of words in working out his flashes of imagination. His grand idea was to make chemistry, which had been developed chiefly in England and France, a German science. Nowhere in his native country could a student obtain a training in the new science, and for this reason Liebig resolved to devote most of the energy of his life to founding a system and school of chemical teaching, instead of devoting himself entirely to original research.

Under his influence, his laboratory at Giessen became the greatest school of

JUSTUS LIEBIG

chemistry in the world, and our own teaching laboratories were afterwards modelled upon it. Liebig made many discoveries, such as chloroform and chloral, and many cyanides. He perfected a method for analysing organic compounds, which in all essential features is still practised everywhere. Working with Wöhler, he made two important contributions to the foundations of his science. But his great and permanent service to the world was not in the isolation and study of compounds and series of compounds, not in the conception of a theory of chemical action, nor even in his valuable views on the chemistry of agriculture, the composition of food, the processes of digestion, and the source of animal heat. His great service to humanity was that he showed how chemistry should be studied, and how it should be taught.

Some poets, like Spenser, are called poets' poets, because they appeal more to poets than to ordinary cultivated readers. Liebig is the chemists' chemist. His name is associated in the public mind almost exclusively with the extract of meat he prepared in connection with his studies of food. This is a sad injustice. Liebig never proposed to use his extract instead of meat, because it contains only a part of the constituents of flesh. His idea, in the first instance, was to turn to account the flesh of animals in Australia and South America, which would otherwise be wasted, when the beasts were bred only for their wool or fat. His extract of meat is only a valuable stimulant, to be consumed together with bread or other vegetable food.

Liebig's title to fame, over and above his fine body of discoveries, is that he is the founder of German chemical science and German chemical industries. He wished to help England, and pointed out, in 1837, our deficiencies and lack of organisation in chemical instruction. His most brilliant pupil, Hofmann, gave the best part of his life in an attempt to arouse British manufacturers, and train a group of British chemists of genius. Liebig was created a baron in 1845. He lived during the last twenty years of his life at Munich, and died there on April 18, 1873.

GABRIEL LIPPMANN

Another Direct Method of Colour-Photography

Gabriel Lippmann, Professor of Physics at the University of Paris, and inventor of colour-photography, was born in 1845, at Hollirsch, in the Grand Duchy of Luxembourg. His father was of Lorraine, and his mother of Alsace, and both by birth and training he combines French and German influence. He was educated at Paris, in the Lycée Henri Quatre. He showed at school a bent towards scientific pursuits, and through one of the most admirable of French institutions he was able to obtain a scientific education at little or no cost.

In order to obtain a large body of well-trained professors for the work of public instruction, the French Government hold open competitions for a prize of three years' free education at the Ecole Normale, which is really a branch of the University of Paris. Many of the finest minds of modern France have won their training in this way. All

that is asked of them is that they shall remain Government teachers for ten years, or redeem themselves by paying for the splendid training they have received. Professor Lippmann entered the scientific department of the Ecole Normale in 1868, and, after a brilliant career there, he went to Germany to study physics and chemistry.

It needed some courage for a young Frenchman to go to Heidelberg immediately after the Franco-German War. But Lippmann's patriotism took the high and useful form of resolving to know all that he could learn from the conquerors of Alsace-Lorraine. He held with Renan that one of the causes of France's defeat was the inferiority of French science in 1870 compared with German science. As a representative of the younger generation of France, he was determined to do what in him lay to make French science again one of the great forces of the world. He studied physiological chemistry, and worked for a German chemist on the albuminous phosphates. Then he abandoned chemistry for physics, and took up the study of electro-capillarity, in which he was afterwards to make his name. He graduated at Heidelberg, and went on to Berlin, and worked for a year under Helmholtz.

Returning to Paris, he won his doctor's degree with a brilliant and original treatise upon the relation between electric and capillary phenomena, and by reason of his genius and knowledge obtained a position in the physical laboratory at Sorbonne. It was a wretched affair, consisting of some sheds and a couple of rooms on the ground floor of a house in the Rue Saint Jacques. In 1883 Lippmann became Professor of Physics in the University of Paris, and Director of the Laboratory at which he had been an assistant. Naturally, he at once began to agitate for proper rooms and appliances, such as were to be found in any German university. After a long struggle he managed to put the laboratories of the University of Paris on something like an equality with the German homes of scientific research. The magnificent work that has recently been done by Curie, the discoverer of radium, and Lippmann himself, and other professors of Paris, clearly shows that when a Frenchman has proper scientific tools he is at least the equal of the German man of science. Yet Lippmann, having had to work in the old sheds for upwards of twenty years, still retains some affection for his dilapidated workshop. It was there that he worked out his famous law of the conservation of electricity, and began his more popular work on colour-photography.

Professor Lippmann did not invent his process of photography by long experiment. He set out from a theory in optics regarding the interference effect of waves of light. The hues of mother-of-pearl, opals, and the iridescence of soap-bubbles are due to waves of light falling on the thin films, and getting mixed up with the waves reflected from the inner surfaces. The direct train of white light-waves meets the train of reflected waves. Some of the waves completely counter-affect one another, and the result is darkness. This is the full interference effect. It can be produced in a photograph plate, by putting a metallic mirror behind the plate at the back of the camera. This is what Professor Lippmann did. The mirror reflected the light back on itself, and gave rise to interference effects within the film of sensitive photographic chemicals. The result of the interference was that the waves were thrown back on themselves, and became stationary waves, and left a record of their forms in the silver salts on which they acted. Ordinary light-waves travel too quickly to leave a photograph of themselves, but in the Lippmann process the photographic film becomes a record of the forms of the waves that fall upon it. The process does for the variously coloured waves of light what the phonograph does for the variously shaped waves of sound.

The photographic plate is developed in the ordinary way, and, if held up to the light, it seems to be a very weak, ordinary negative. In order to bring out the colours, the photograph must be looked at in the direction of the regularly reflected ray. If it is regarded from another point only a colourless image is seen. Professor Lippmann used his process for scientific purposes in obtaining photographs of the spectrum. He did not want to work at a commercial application, but it was not until he had patented his ideas that some photographic firms took the matter up. It was a German firm that first placed on the market an improvement of the Lippmann process.

In 1911 Professor Lippmann worked out a still more original and astonishing system of photography. It is known as "integral photography," and, so far as we know, it has not yet been placed on the market. A sensitised plate is coated with a large number of small globules of glass, each less than 100th of an inch in diameter. These

tiny globules act as miniature eyes, and the sensitive plate behind them serves as a retina. No camera is necessary.

The plate is merely exposed so that the object or scene is mirrored upon it. The little beads of glass act as lenses, and transmit each a minute picture on to the photographic plate. The plate is then developed, and made into a transparency, and a light is placed behind it so as to send the radiance through all the globules. All the minute pictures are then combined into one image of the original object, far surpassing in relief and distinctness an ordinary photograph. Professor Lippmann leaves it to other inventors to develop this new system. The great difficulty is getting glass globules made cheaply and regularly. The minute glass beads of commerce are too irregularly formed to act as good lenses. If it were possible to make dies for stamping out beads from transparent sheets of collodion, the new process might become commercially practical.

SIR OLIVER LODGE

A Foremost Student of Matter and Mind

Sir Oliver Joseph Lodge, one of the foremost of contemporary physicists, and a pioneer in wireless telegraphy, was born at Penkhull, Staffordshire, on June 12, 1851. His father, who was a potter, sent him to Newport Grammar School until he was fourteen; then took him into the works with him, where he was in a fair way to becoming a successful maker of pottery, but scarcely to helping the world along the path of science. But as in old days a piece of burnt stick used to find its way to the embryo artist, or a piece of clay invite the manipulative fingers of the born sculptor, so some old copies of the "English Mechanic" arrested the attention of the little potter. The work carried him into a new world, and drew him, with penny encyclopædias as finger-posts, to the study of science, of whose existence he had had no conception. But it was not until Oliver Lodge had served his full seven years among the clays and spinning-wheels that his father realised he had a genius upon his hands, and sent him up to London to hear Tyndall and study at University College.

There, after matriculating, he was appointed Demonstrator of Physics, took in turn his B.Sc. and D.Sc. degrees; then passed on to Liverpool University College as Assistant Professor of Physics and Mathematics, gained the Rumford Medal, began his long series of investigations of electric phenomena, and turned them to practical account when acting as scientific adviser to an electrical power storage company. He was promoted to the Chair of Physics at Liverpool University, and proceeded thence to the new Birmingham University, of which he has been Principal since 1900. Both by his writings and teachings Sir Oliver Lodge has given a powerful impulse to the scientific education of latter-day England. From his lecture-rooms have issued students informed and inspired by himself whose work in the future should prove of signal importance to their generation. But his personal contributions to contemporary science have had high value. Especially is this so in regard to wireless telegraphy, in which he was making practical experiments long before the world had heard the name of Marconi. It was while training a host of bright youths who have passed through his hands that he conducted his researches into the phenomena of ether, electro-magnetic waves, and wireless telegraphy, work necessitating a multitude of refined experiments, carried out as he says, in his spare moments. With Dr. Muirhead he invented a method of wireless telegraphy which was the forerunner of the more comprehensive Marconi system. Sir Oliver Lodge was not the creator of the wireless system; many men had worked in the field before and simultaneously with him. But he collated all the results of work done, and in a book of the highest value he told the world what had been attempted and accomplished, so that the expert and the striving student might, in point of knowledge as to what had gone before, be on terms of approximate equality.

He interpreted the message of Clerk Maxwell and of Hertz. Clerk Maxwell had predicted the discovery of electro-magnetic waves; Hertz found them. Lodge harnessed them for the purpose of aerial messages. He was an interpreter when the science was a congeries of nebulous theories and unapplied discoveries.

Besides his work in regard to wireless telegraphy, he has carried out interesting experiments with a view to fog-dispersal by means of electric discharges. He has filled a bell-jar with smoke, both dry smoke and damp smoke; then, by electrifying the clouded atmosphere, has seen the smoke coagulate and fall. He has filled a room with dense smoke, electrified it, and cleared the air completely. He holds that ships equipped with an instrument for electrifying the air might dispel the fogs by which they

are shut in. Under certain conditions clouds might, he believes, be made to discharge their rain. Much that he has been able to accomplish in directions such as these remains a basis for work of the future. He inherited a legacy from his predecessors in science; he will hand on a richer endowment to those that come after, and it may be that among his own students someone will be found to wear his mantle. But the results will come more quickly in future. A Lodge invents swift and exact machinery, to take the place of rule-of-thumb methods to which he and those contemporary with him in his youth were condemned, and success is achieved

SIR OLIVER LODGE
Photograph by Ernest Mills

by means of that machinery at less cost in time and labour than seemed possible to those with whom he began his task.

Sir Oliver Lodge has traversed much of the debatable ground of physics and psychology, and as President of the Society for Psychical Research has, with Sir William Crookes and other distinguished men, investigated a considerable body of evidence bearing upon what to the outside world is commonly known as spiritualism. He asserts that telepathy or thought-transmission is proved to demonstration, a statement in which he does not carry with him the majority of men distinguished in science. In this connection it is important to note that in 1911 a sum of £1000 was for six months privately offered in London for satisfactory proofs of thought-transference, and, there being no evidence forthcoming, the offer was advertised in the "Times," but, without limiting the amount to £1000. It said: "Persons applying are requested to name their own terms for evidence that will stand cross-examination, and to state whether or not their communications are to be treated as confidential."

The reward has not been won. Whether the circumstances have induced modification of the views of Sir Oliver Lodge does not appear. He laid it down to an interviewer some little time ago, "The distance between England and India is no barrier to the sympathetic communication of intelligence in some way of which we are at present ignorant. Just as a signalling key in London causes a telegraphic instrument to respond instantaneously in Teheran, which is an everyday occurrence, so the danger of death, or death of a distant child, a brother, or husband may be signalled, without wire or telegraph clerk, to the heart of a human being fitted to be the recipient of such a message."

JAMES CLERK MAXWELL
The Discoverer of Electric Waves

James Clerk Maxwell, one of the greatest of modern men of science, the son of a Scottish laird and a Northumberland lady, was born at 14, India Street, Edinburgh, on November 13, 1831. His father was a lawyer who dabbled in scientific experiments. After the birth of his son he retired to his country estate near Castle-Douglas, and devoted himself to the education of his only child. At ten the boy was sent to Edinburgh Academy, where he received the name of "Dafty," and for some years he did not show any promise. But his defects of mind were largely due to shyness, and he cured himself at thirteen by a curious device.

He made a plan of the large window of the room in which he had to repeat his lessons, and wrote the words in the spaces representing the window-panes. Then by gazing at the actual window the words came back to him in the order he had written them, and he ceased to be the dafty one of the school. His great fear was that by changing his place in the class he might be obliged to stand where he could not see all the window-panes.

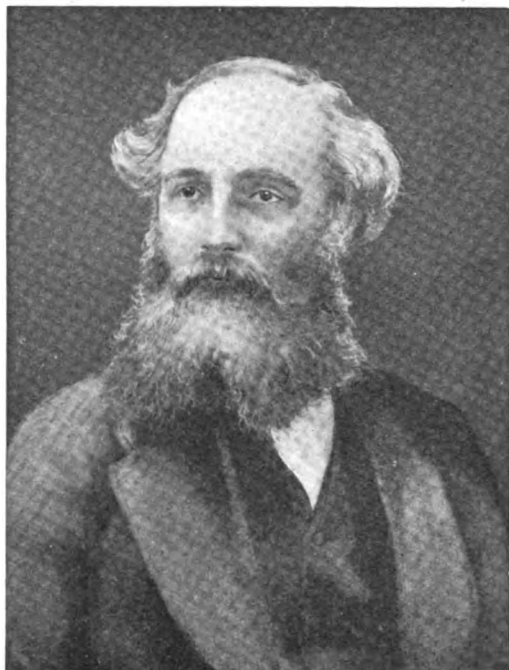
When he won the prize for mathematics, his delighted father, who acted more as an elder brother than as a parent to him, joined

the Royal Society of Edinburgh and took the boy to the meetings. And of course his scientific education was quietly but thoroughly continued in talk with his father. Mrs. Clerk Maxwell had died, and the laird lavished all his affections on his son and made him his companion. At fifteen the brilliant lad made his first contribution to science by drawing some curious ovals, which were so remarkable that Professor Forbes brought them before the Royal Society. The boy then took up the study of magnetism and the polarisation of light; but as he pursued these researches while still continuing his ordinary schooling, he became unwell. Alarmed at the results of his precocity, his father ceased to take him to scientific meetings. By this time, however, he was able to work out many things for himself. At sixteen he entered the University of Edinburgh, and threw himself into many branches of science. Then came the struggle with his father. The old laird wanted his son to study law, but James said he was more interested in "laws of another kind"—scientific laws, of course. Though his father did not want to lose his son's companionship, and was afraid he would permanently injure his health by over-study, he at last gave way.

Clerk Maxwell went up to Cambridge in the autumn of 1850, with a mass of knowledge that was really immense for so young a man, but it was in such a state of disorder that his tutor was appalled. Through having been largely self-trained, he had studied widely but without method. His strength of intellect was superb, but he had very little knowledge of how to use it to advantage under the special conditions of university examinations. Yet he won the position of Second Wrangler.

At Cambridge he gave up much of his time to helping a fellow-student who had hurt his eyes with experiments on light, and could not read for his examinations. The man got through, but the strain produced in Clerk Maxwell an attack of brain fever that lasted for a month. It was probably this that made him take only second place in the mathematical Tripos.

He won a fellowship at Trinity, and then settled down to the work of his life. Intentionally he had not studied electricity until he had obtained a mastery of mathematics. But he now took up Faraday's work, and, entering into correspondence with the great electrician, proceeded to acquire in a methodical manner all the existing knowledge on the subject. Faraday had shown that the interaction between two bodies by means of electricity was not merely action at a distance. There were actual lines of force running through the mysterious medium, the ether, and conveying an electrical influence from one body to another. The trouble was that the ether of Faraday's electrical theory was different from the medium required in the elastic-solid theory of light which the great mathematicians of the old school had developed.

It was Maxwell's life-task to prove that there was only one medium in which electrical lines of force acted, and that light and electric waves were identical in nature, both being forms of electro-magnetism. He

JAMES CLERK MAXWELL
Photograph by Emery Walker

made the astonishing discovery that the electrical ether would transmit electrical waves with a speed exactly equal to that with which light was known to be transmitted. Hence any medium which could explain electrical action could also explain light. This is Maxwell's greatest achievement in the foundation of the electrodynamic theory of light.

In his younger days Maxwell had won, by a fine piece of mathematical work in connection with the problem of the rings of Saturn, the prize founded in memory of Adams, who discovered the planet Neptune without studying the skies. Adams merely

took into account some irregularities observed in the movements of Uranus, and by mathematics calculated the size of the disturbing body, its place in the solar system, and the position which it would occupy in the skies at a given time. When a Cambridge astronomer looked through his telescope at the spot indicated by Adams's calculation the great new planet was perceived. Maxwell performed a somewhat similar task on a larger scale.

His theory required him to suppose that electrical action at a distance was produced by a train of electrical waves. He worked out the properties of these unknown waves, and gave their measurements, and, as soon as Hertz managed to invent an instrument for detecting the undulations in the ether, the electric waves were found, and, when measured, proved to be what Maxwell had predicted they would be. Maxwell is thus the original theoretic founder of all systems of wireless telegraphy and telephony. His magnificent feat is one of the most wonderful examples of the power of the human mind. Simply by developing the mathematical consequences of an experiment with a magnet and iron filings, from which Faraday obtained the idea of lines of force, he simplified the theories of light and electro-magnetic effects, and worked out the actual form of electric waves in a still more mysterious ether.

At the present time it is not quite certain that even his simplified kind of ether actually exists. An American man of science, Michelson, recently found out how to measure the hundred-millionth part of a small distance, and he determined the fixity of the ether by comparing the velocity of light at two different points during the change in the earth's position as it sweeps around the sun. It seems that the ether is not fixed near the surface of the earth, but takes part in the earth's movement, This idea, however, gives rise to other difficulties, and a German mathematician, Einstein, now proposes to abolish the ether. But here more difficulties occur; and men of science all over the world are now divided in two warring camps over the question of the existence or non-existence of Maxwell's ether. On the other hand, Clerk Maxwell's electric waves are a fact, through whatever medium they move.

Though Maxwell's great paper on electro-magnetism appeared in 1864, some years passed before his theory arrested general attention. It was not until his work on "Electricity and Magnetism" appeared, in 1872, that his theory was accepted. It is still a matter of surprise that though he was surrounded at the Cavendish Laboratory with a band of young physicists who firmly believed in his ideas, no attempt was made by them to furnish experimental proof of their master's deductions. It was Helmholtz, always on the alert on the side of progress, who suggested to his pupil, Heinrich Hertz, to take up the experimental investigation of the problem. A great number of scientific men were reluctant to abandon the old idea of an elastically solid ether in favour of Maxwell's conception. In our country Lord Kelvin refused to agree to Maxwell's views. It was not until Hertz discovered the electric waves that all this opposition ceased. In the meantime Maxwell had fallen ill in the spring of 1878, and after a long illness he died on November 5, 1879. In the course of his career he was Professor in Marischal College, Aberdeen, in 1856; Professor at King's College, London, in 1860; and Professor of Experimental Physics at the Cavendish Laboratory, Cambridge, from 1871 to his death.

DMITRI IVANOVITCH MENDELEEFF

Discoverer of the Master-Key of the Elements

Dmitri Ivanovitch Mendeleeff, the master-chemist of Russia, was born at Tobolsk, Siberia, on February 7, 1834, the seventeenth and youngest child of a schoolmaster. Soon after his birth his father became blind and lost his position, and the very large family was entirely dependent upon the efforts of their mother. Happily she was a woman with remarkable knowledge, energy, and force of character. She set up as a glass-maker at Tobolsk, and for many years managed the glass-works entirely herself. Out of the profits she made, she was able to bring up and educate her swarm of children. Her noble story is told by Mendeleeff in the introduction to his great work "On Solutions," which he dedicated to the memory of his mother in language of high beauty and moving power.

The boy studied at the Siberian school of which his blind father had been master, and at sixteen went to St. Petersburg University, with the intention of taking up chemistry, which, at this early age, had become the passion of his life. The authorities, however, transferred him to an institute for training teachers, with the object of getting him to follow in his father's footsteps. Whilst at the institute the boy made his first contribution to chemical science, and was sent as a teacher to the Crimea. But

as the Crimean War interfered with the instruction given in the neighbourhood, the young man was transferred to Odessa.

He still persisted in wanting to be a chemist rather than a schoolmaster, and he sufficiently distinguished himself at twenty-two to be allowed to go up to St. Petersburg University. There he obtained his degree of Master of Chemistry, and became a lecturer and private teacher recognised by the university, but not on the salaried staff. While still in his twenty-second year Mendeleeff had taken up the study of the great problems with which his name is for ever connected. In a series of remarkable papers laid before the leaders of the university, he pointed out the lines on which all large advance could alone be made. By this time the glass-works in Siberia were becoming very profitable, and his mother, proud of the scientific genius of her youngest son, was able to send him some money to pay the expenses of his difficult and laborious researches.

Mendeleeff in 1859 obtained from the Minister of Public Instruction permission to travel. He went to Heidelberg, set up a small private laboratory, and spent all his time in the study of chemical compounds. He returned home in 1861, and two years afterwards was appointed Professor of Chemistry at the Technological Institute of St. Petersburg. Three years later he was made Professor of Chemistry at the University.

He was a man with a passion for hard work, and there is no branch of chemical science which he has not enriched. But his reputation mainly rests upon his contributions to physical chemistry and chemical philosophy. His great work "Principles of Chemistry," appeared in 1869. In it he developed the grand chemical generalisation which is now often called Mendeleeff's law, or the periodic law. This law is one of the most striking things in the history of science, and it has exerted a profound influence in the development of chemical research. It is one of the master-keys of knowledge. Not only did it bring all known facts into systematic order, but it showed what facts remained to be discovered, and what properties these unknown elements possessed.

It had long been noted that certain elements were remarkably similar to each other. Thus the metals sodium and potassium are both white, soft, and easily oxidisable metals, forming soluble salts with almost all acids. These salts resemble each other in colour, form, and other properties. Some metals afterwards discovered have also a strong resemblance to potassium and sodium, and their atomic weights also increase progressively. Similar facts have been observed with other groups. But it was not until John Newlands, in 1863, called attention to the fact that if elements be arranged in the order of their atomic weights a curious fact becomes noticeable. All elements may be so arranged, said Newlands, that the difference between the number of the lowest member of the group and that immediately above it is seven. In other words, the eighth element starting from a given one is a kind of repetition of the first, like the eighth note of an octave in music.

Newlands incurred a good deal of ridicule; and it was not until his discovery was confirmed by Mendeleeff and worked out into the master-law of chemistry that the value of the English chemist's remarks was recognised by his countrymen. Mendeleeff seems to have made his discovery independently, and a German chemist, Lothar Meyer, also found that a periodic law ran through the elements.

But it is to the Russian chemist that the establishment and working out of the law are mainly due. He found that the weight of various elements did not fit in with the weights assigned them by his law, but the law was proved to be right, and more delicate experiments showed that the actual weights had been wrongly arrived at. The law has now been adopted as the groundwork of classification of chemical substances, and many empty places that Mendeleeff left for elements then unknown, but classified and weighed in advance, have been filled in by discoveries that have been found to agree with his calculations. So the periodic law has become one of the most extraordinary examples of the power of the human mind to anticipate the discovery of facts, and point out beforehand the properties they will be found to possess.

Having arranged the elements according to his periodic law, Mendeleeff was able to indicate the existence of new forms of elementary matter, and even point out the probable sources of the undiscovered substances. It was this power of divination which first attracted attention to the law, and quickened the interest with which its development was regarded by men of science. The great law also seemed to show that the ancient alchemists were not

wrong in their theory of a primordial form of matter out of which the various elements had been evolved. And though Mendeleeff himself hesitated to adopt this view, it was at last confirmed by the discovery that the light element helium was one of the things produced out of the heavy element radium. After training two generations of Russian chemists, and making his own name famous throughout the world, Mendeleeff died at St. Petersburg on February 2, 1907.

HANS CHRISTIAN OERSTED

The Discovery by Chance of Electro-Magnetism

Hans Christian Oersted, the discoverer of electro-magnetism, was born on August 14, 1777, in the isle of Langeland, in Denmark. His father was an apothecary on the island, and Hans was brought up to the same profession. He was taught to read and write by the wife of a German barber; from the barber he learnt German. He also picked up Greek and Latin and French from a minister's son, having at an early age an uncommon passion for knowledge. At twelve he became his father's apprentice, and took to studying chemistry, and four years later he went to Copenhagen University to learn pharmacy.

This was the opportunity for which he had been waiting. Far from confining himself to the one subject on which his living seemed to depend, he threw himself into various fields of knowledge with brilliant results. He passed in pharmacy, won a prize in medicine, and a doctorship in philosophy. Instead of letting him return as an apothecary to his native island, the professor of surgery engaged him as an assistant. While carrying out his duties, Oersted took up chemical research, and finely distinguished himself by making the first classification of earths and alkalies.

When the electric battery became generally known, in 1800, Oersted was one of the first to make experiments on the alkalies and acids set free by the electric current. So striking was the work he did that at twenty-four he was allowed to travel for five years in foreign countries at the expense of the State, with a view to enlarging his knowledge of modern science. He returned to Denmark with a theory that all the forces of Nature were identical in their ultimate nature, and on being appointed, in 1806, Professor of Physics at Copenhagen University he gave much time to teaching this doctrine.

It was a pure theory when he took it up, and sixteen years passed before he was able in any way to substantiate it by experiment. All the researches he undertook in his laboratory were fruitless. But in the summer of 1822 he was showing his class some of the properties of an electric current, and there chanced to be a magnet on the table near the wire. In the middle of the lesson, he placed the wire carrying the current above and parallel to the magnetic needle of the compass. The needle was at once deflected. By bringing the wire nearer he increased the deflection. It is only in certain positions that a live wire will turn a magnetic needle from its ordinary position; and it is for this reason that some years passed between the discovery of the electric battery and the accidental discovery by Oersted of electro-magnetism.

Before Oersted made his simple but tremendously important experiment, men of science knew something of electricity, and something of magnetism, but they knew these two forces as things distinct from each other, as light is from gravitation. By one stroke of experimental fortune Oersted showed that electricity and magnetism were not independent domains of physics, but intimately connected forms of energy. Later on, Faraday completed Oersted's sudden and unexpected achievement by showing that a magnet can generate an electric current in a conducting wire. Then Clerk Maxwell developed Faraday's experiments, and showed that light was also an electro-magnetic phenomenon.

So gradually Oersted's theory of the identity of the forces of Nature was worked out. Even gravitation is now supposed to be a matter of electro-magnetic attraction, and the atom has been broken up into electrical centres of energy. But what counts in science is not a mere theory, but the experiments, observations, and calculations that reduce a mass of scattered facts to an intelligible order. Oersted is for ever famous because he proved, by actual experiment, the intimate connection between a magnet and an electric current. He also carried out some original and important researches on the compressibility of water, and by means of a thermo-electric cell that he constructed in 1823 he decomposed aluminium. He died at Copenhagen, March 9, 1851.

WILHELM OSTWALD

Pioneer in a New Field of Industry

Wilhelm Ostwald, the founder of the Leipzig School of Chemistry, was born at Riga, in Russia, September 2, 1853. He was first educated at a German school in that town, and he afterwards studied

chemistry and physics in the Russian University at Dorpat. Here he became a private tutor recognised by the university, but not on the salaried staff. He received a little money for assisting in the laboratory, but it was not enough to live on, and the young chemist made both ends meet by giving lessons in music and painting. In 1880 Ostwald returned to Riga, and taught in the Polytechnic of his native town. The inspiring effect of his ideas and instruction was seen in the rapid way in which his laboratory grew. The number of students had more than doubled by 1887, when he was called to the Chair of Physical Chemistry at Leipzig. His first year's work at Leipzig was discouraging in its results, but by this time his name so shone over the whole scientific world that the old laboratory was packed with students. A larger laboratory had to be built in a few years, and even the new building soon became too small for Ostwald's pupils.

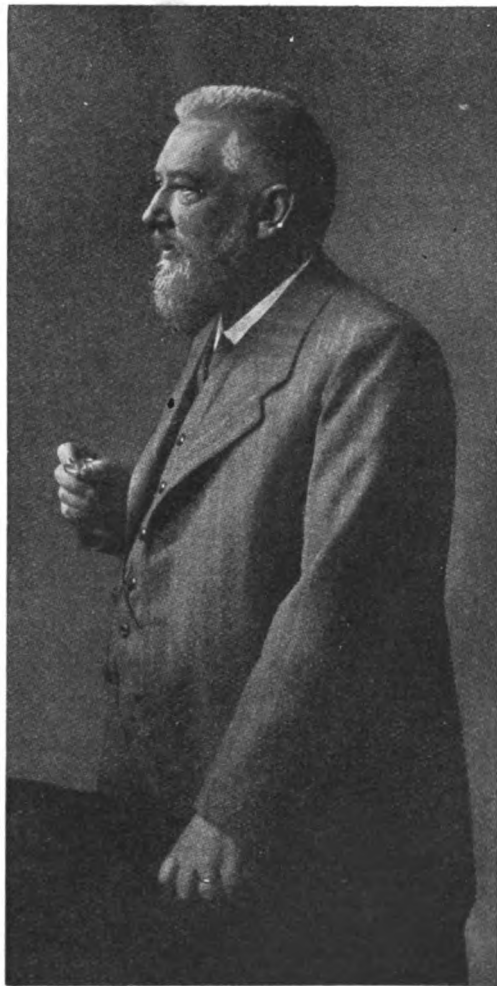
Ostwald is a leader of men, and he has a force of personality which attracts and inspires. He is always a little in advance of his age, and he has a fine literary talent which enables him to interest any audience. It is to him that is largely due the extraordinary development of physical chemistry in the last twenty years. We owe some of the fundamental discoveries in this new branch of science to Van't Hoff, a Dutchman; to Arrhenius, a Swede; and to Nernst, a German; but Ostwald took up the work of these men, and developed it to a point at which the world must accept it.

Ostwald is a fighter of the stamp of Huxley. A large majority of the younger physical chemists of today have worked in his laboratory, and in matters of pure chemistry his opinions always have great weight. It is only as a general philosopher that Ostwald encounters much opposition. His "Textbook of Physical Chemistry," written in 1884, opened a new field. His book on the "Scientific Basis of Analytical Chemistry" brought about a reformation in chemical analysis.

He has not forgotten, amid his chemical studies, the arts by which he began to earn his living. His holidays are spent in sketching with a form of pastel of his own invention, and he is still a good musician, with an interest in the scientific problems of this purest of arts. In 1906, at the height of his fame and his power, he voluntarily resigned his professorship at Leipzig, and retired to his country estate. This was the result of his idea of happiness. He had, he considered, done his share of official work, and he wanted to enjoy more of the pleasures of family life, and be free to carry out work for which he could find no opportunity while directing the institute at Leipzig.

PARACELSUS

The Mystic Founder of Medical Chemistry

Phillipus Aureolus Theophrastus Bombast of Hohenheim, who called himself Paracelsus, was born at Einsiedeln, Switzer-

WILHELM OSTWALD

land, on December 17, 1493. His father was a doctor, and taught him the first rudiments of medicine. After studying at Basle, Paracelsus led a wandering, adventurous life among the Tartars of Poland and the peasantry of nearly every country in Europe. His aim was to study and test all kinds of popular remedies. In 1526, when he was appointed a professor at Basle, he publicly

burnt the works of all the old authorities on medicine, and introduced various chemicals as drugs. Persecuted by most of the medical men of Germany, he lost his professorship, barely escaped prison, and died, Sept. 23, 1541, in wretched circumstances, at Salzburg.

This reformer of chemical medicine had something of the charlatan in his nature. He thought that organic bodies were composed of mercury, sulphur, and salt, and that diseases were caused by too great an increase or decrease of one of these substances. Magic, alchemy, and astrology were mixed up in his medical theory. He

THEOPHRASTUS PARACELSUS

From the painting by Rubens

held that shooting-stars caused plagues, and that planets had an influence upon the secretions of the human body. Nevertheless, he effected an important revolution in chemistry by seeking for medical chemicals instead of trying to turn base metals into gold. He enriched medicine with a large number of valuable preparations, and worked out better methods for obtaining essences and extracts. He was the author of the modern doctrine of specifics, and did much to change the apothecary from a mere herbalist into a chemist. Pharmacy owes very much to him. His followers not only enriched medicine but also considerably advanced chemistry.

SIR WILLIAM HENRY PERKIN

Founder of the Coal-Tar Industries

William Henry Perkin was born in London, March 12, 1838. His father was a builder, and wished him to study as an architect, so as to be able to work with his brothers. The boy tried carpentering, but became more interested in engineering. When he was twelve, a young friend showed him some chemical experiments, and, carried away by the hope of making some important discovery, the boy fixed on chemistry as his calling. Nothing that his father said could turn him to any other profession.

Educated at the City of London School, he attracted the lecturer in chemistry by his passion for study, and was appointed to assist him. When Sir William was fifteen, the lecturer talked over his father, and the boy was sent to work under Hofmann at the Royal College of Chemistry. In spite of his youth, Hofmann soon made him one of his assistants—a position of toil, as well as honour. Perkin was so occupied in the day-time that he could carry out no researches for himself, and it was only by fitting up a small laboratory at home that he could do original work.

In the Easter holidays of 1856 he was trying to make an artificial quinine out of coal-tar product. He only obtained a muddy, dark precipitate, from which he vainly tried to extract the colourless crystallising substances that he wanted. But, instead of throwing the muddy waste stuff away, he was struck with the idea of coal-tar dyes. He tried the same experiment with aniline black, and extracted a beautiful mauve dye. It was a flash of supreme originality that led him to investigate the colouring matters in coal-tar. Hofmann, his master, objected to experiment with anything that did not crystallise, and strongly disliked working with anything coloured. So, though he directed Perkin's attention to aniline, the boy's discovery of the dye was strikingly original work.

Resigning his position under Hofmann, Perkin went to Pullar's works at Perth, to study the process of dyeing. Then, with the help of his father, who risked in the enterprise most of the money he had saved, the young chemist established his famous dye-making works at Greenford Green, near Harrow. He had at first considerable difficulty in selling his dye to dyers and

printers; but, unlike many later inventors who followed in his footsteps, he was from the beginning able to compete with vegetable dyes. For purple dyes were at the time so fugitive, especially when applied to silk, that sometimes a lady would have a new violet ribbon in her hat in the morning, and in the evening it would be a sort of red ribbon. Coal-tar mauve was much more permanent than this.

But Sir William's greatest success was his later discovery of a commercial method of making from a coal-tar product a dye similar to that obtained from madder root. In 1873 the demand for Turkey-red dyes of this sort was so great that it became necessary to enlarge the Greenford works

WILLIAM HENRY PERKIN

two or three times. Sir William Perkin did not care to do this. He did not want to be entirely absorbed in the commercial exploitation of his discoveries, so the business was sold; and from 1874 to his death, on July 14, 1907, Sir William devoted himself entirely to pure science.

He discovered the famous Perkin reaction, which has proved an instrument of chemical research of high importance. He magnetised certain substances that polarise light, and established a relation between magnetic polarisation and chemical constitution which may prove of high value in the future, when the electrical properties of matter are more finely traceable. At present his discovery of coal-tar colours seems to be his most far-reaching work. It has not only become the foundation of a huge industry, but it has led to the discovery that all, or nearly all, the colouring matters found in Nature—in flowers, roots, dye-woods—are related to coal-tar.

Knighted in 1906, Sir William Perkin died near Harrow on July 14, 1907.

WILLIAM HENRY PERKIN
Professor and Inventor

William Henry Perkin, the Waynflete Professor of Chemistry at Oxford, and one of the most distinguished of the professorial inventors of our times, was born at Sudbury, near Harrow, on June 17th, 1860, the eldest son of Sir William Henry Perkin, the great chemist who discovered aniline dyes. As was perhaps natural, three of Sir W. H. Perkin's sons followed in his footsteps, and two are members of the Royal Society, while the third, now a consulting chemist, has made his mark as a teacher, experimenter, and writer.

Professor W. H. Perkin was educated at the City of London School and the Royal College of Science. Afterwards he went to the University of Würzburg, and took his Ph.D. degree, and then passed on to a course of study at Munich, where, for three years, he was a *Privat docent.* In 1887 he became professor of chemistry at the Heriot-Watt College, Edinburgh, and stayed there five years. In 1882 he was appointed professor at the University College, Manchester, and, after a distinguished course there for twenty years, was elected, in December, 1912, to the Waynflete Professorship at Oxford.

Dr. Perkin is an honorary doctor of Science of Cambridge, and LL.D. of Edinburgh and St. Andrews. He received the Davy medal from the Royal Society in 1904. His contributions to original research have been numerous and important, one having a popular significance, and another a sensational outlook. On the popular side is his invention of the "Non-Flam" process for permanently fireproofing cotton goods. This has been fully described and discussed in our pages, 3964–6. It is hoped that this invention will counteract the extreme dangers of using flannelette. Then, on his fifty-second birthday, Professor Perkin announced the discovery of a method of making artificial rubber. If this could be done so as to compete in cheapness with the natural product, it would have a revolutionary effect.

Professor Perkin has written a book on "Organic and Inorganic Chemistry," jointly with Professor F. S. Kipping, of University College, Nottingham. Professor Kipping was assistant to Professor Perkin at Edinburgh, and they cemented their friendship and association by marrying sisters. At Oxford a new chemical laboratory is to be erected for Professor Perkin in University Park; and he, in the prime of life, is one of the searchers for knowledge from whom great things may be expected confidently.

JOSEPH PRIESTLEY
A Free-Lance of Science who Discovered Oxygen

Joseph Priestley, who had the curious art of making fine discoveries by following wrong theories, was born at Fieldhead, near Leeds, on March 13, 1733. He was the son of a clothmaker, and, receiving a religious education, he became a Dissenting minister of advanced opinions, which were not always to the taste of his congregations. About 1769 he met Benjamin Franklin in London, and, getting on friendly terms with him, was inspired with a new ardour for scientific research.

In matters of science Priestley was as unorthodox as he was in religion, and just as vehement in arguing his views. He held, for instance, that things burnt because of a fiery principle they contained. He was the wildest and most brilliant of scientific free-lances, and, without knowing it, forged the weapon by which he was overthrown. Indeed, he went to Paris and placed the instrument of his defeat in the hands of his friendly opponent, Lavoisier. In August, 1774, he was amusing himself by studying the action of heat on various substances.

From red precipitate, or oxide of mercury, he obtained a gas in which a candle burned with a remarkably vigorous flame. He put a mouse in the gas, and it grew very lively. He breathed some of the gas himself, and found it gave him a fine sense of exhilaration. He had discovered oxygen. In later experiments he found other sources of what he called "pure air." He showed Lavoisier how to make oxygen, and the Frenchman soon proved that all forms of combustion were produced by the oxygen of the air entering into chemical combination with burning substances. But Priestley fought to his death for his non-existent fiery principle, mysteriously hidden in all combustible forms of matter.

Priestley was a careless, unmethodical experimenter, with brilliant flashes of originality. He made many important discoveries in chemistry, but generally left it to more careful men to develop them fully. He started the hares that others bagged. Some of his best work was done between 1773 and 1779, while he was acting as literary companion to the Marquis of Lansdowne. He had practically no duties, and worked at chemistry and travelled abroad. But, finding a congregation at Birmingham willing to listen to his views on religion, he accepted the ministry of a chapel there, and remained until 1791. Lansdowne allowed him £150 a year, and some friends raised a further sum of money for him, so that he might continue his scientific researches. His political views were as advanced as his religious ideas; his writings were condemned in many parts of the country, and Burke denounced him in the House of Commons. So when his friends celebrated in Birmingham the taking of the Bastille in 1791, an angry mob came out to attack the Republicans. They burnt Priestley's dwelling-house and chapel, and one of his sons barely escaped with his life. Priestley went to Hackney for three years, and in 1795 followed his sons to America. He settled in Northumberland, Pennsylvania, and died on February 6, 1804.

JOSEPH PRIESTLEY
From a photograph by Emery Walker

SIR WILLIAM RAMSAY
A Modern Transmutationist

Sir William Ramsay is descended from a line of manufacturing chemists. He was born at Glasgow, October 2, 1852. He

received his scientific training at Glasgow University, but adopted medicine as his profession, and entered the laboratory of an analyst to gain experience. After studying under Lord Kelvin, he went to Tübingen, and, returning at twenty-one to his native town, he became assistant to a chemical professor, and afterwards tutorial assistant in chemistry at Glasgow University. In 1880 he was appointed Professor of Chemistry at the University College, Bristol, of which institution he was quickly made Principal. In 1887 he became Professor of Chemistry at University College, London.

Sir William first became generally known for the work he did in collaboration with Lord Rayleigh in the discovery of argon, a new gas in the atmosphere. Afterwards he worked on the subject alone, and succeeded in isolating neon and several other new gaseous elements in the air. In 1895 he was still studying argon, and trying to trace its presence in certain minerals. One of these minerals was cleveite. On heating it in a furnace and throwing its light on a spectroscope, he obtained an extraordinary spectrum. The lines on it were similar to those seen in a spectrum of sunlight in 1868. They represented a mysterious, light element unknown on earth, and known only to astronomers. It was called helium, or "sun-matter." Sir William Ramsay's discovery of it in the minerals of our earth completed one of the most remarkable achievements in modern science.

Helium has since proved to be a more extraordinary form of matter than anybody dreamt of. In the hands of Sir William Ramsay it has entirely upset all ideas of the stability of the material structure of the universe. Soon after radium was discovered, two young men of science from Cambridge and Oxford, Professor Rutherford and Mr. Frederick Soddy, were working together on the problems of radio-activity at Montreal. As a consequence of some remarkable discoveries, they suggested that one of the products of decomposition of the emanation from radium salts would prove to be helium. Sir William Ramsay thereupon invited Mr. Frederick Soddy to come to London, and collaborate with him in working out the real facts of the case.

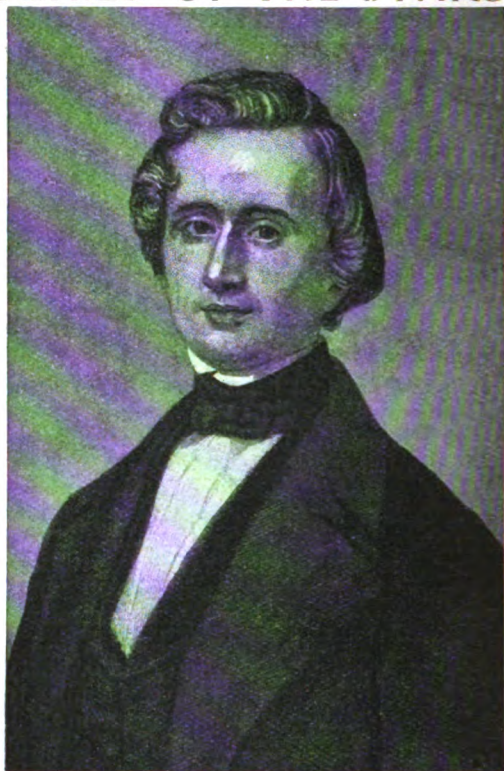
The two experimenters dissolved some radium in water, and by a very ingenious device collected and purified the luminous gas that rose above the water, and then examined it by means of the spectroscope. After the gas had collected for two days, it was examined, and the spectrum of helium was observed. Ten days afterwards the evolution of helium atoms from radium atoms was so far advanced that the material into which the luminous gas had changed was collected. So that the idea of the transmutation of the elements, formed in the days when mankind was ignorant of the existence of the true elements, was at last proved to be an actual fact.

In February, 1913, Sir William Ramsay announced to the Chemical Society that he had discovered helium in the interior of a vacuum glass tube that had been used for the production of X-rays. He first broke some old bulbs and burnt the glass, and studied the gases obtained from it, and obtained the spectra of helium, neon, and argon. Then, instead of breaking the glass, he heated it and collected the gases, and again discovered helium and a small quantity of neon. At the present time there is a great deal of dispute concerning the interpretation of these discoveries. Some men of science contend that the glass and the metal points in an X-ray tube contain helium, which is disengaged by the electric charge. If this is so, many common elements that are supposed to be free from all admixture with other forms of matter are really adulterated with helium and neon and other light materials. Sir William Ramsay, however, thinks that it is another case of the actual transmutation of matter.

Repeating his first experiment with radium dissolved in water, Sir William has recently obtained neon instead of helium. Now, the atomic weight of helium is 4 and that of oxygen is 16, and that of neon is 20. So Sir William suggests that in certain circumstances helium and oxygen combine to form neon. Some years ago Sir William Ramsay and Mr. Cameron obtained lithium from copper. Then, working by himself, he found that, under the influence of radium emanation, silicon gave some carbon dioxide, while with thorium, out of which gas mantles are largely made, carbon dioxide was again obtained.

The conclusion he draws from these experiments is that the element silicon tends to break down to carbon, and this in the presence of oxygen becomes carbon dioxide, better known perhaps as carbonic acid gas. At present the theory of transmutation can scarcely be said to be a generally acknowledged idea in science. But if it is at last borne out by widely repeated tests, Sir William Ramsay, as the main discoverer of the new alchemy, will rank among the very greatest men of science.

TELLERS OF THE MYSTERIES OF THE STARS

PIERRE SIMON LAPLACE

JEAN JOSEPH LEVERRIER

HERBERT HALL TURNER

RICHARD ANTHONY PROCTOR

The two lower portraits on this page are by Messrs. Elliott & Fry

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ASTRONOMERS

PIERRE SIMON LAPLACE

The Diviner of Celestial Mechanics

THIS "Newton of France," as he has often been styled, was the greatest of the band of brilliant mathematicians who completed what Sir Isaac Newton had begun, and traced out all the workings of the law of gravitation in our solar system. The corner-stone of this elucidation was Laplace's subtle study of the causes of the acceleration in the movement of the moon, which he published in a paper of the year 1787. But the "Mécanique Céleste," the "Heavenly Mechanism," was the appropriate title of the great work in which Laplace finally exhibited the gravitational relations of sun, planets, and satellites. Miss Agnes Clerke, the historian of astronomy, remarks of this work that "as a mere machine, the solar system, so far as it was then known, was found to be complete and intelligible in all its parts; and in the 'Mécanique Céleste' its mechanical perfections were displayed under a form of majestic unity which fitly commemorated the successive triumphs of analytical genius over problems among the most arduous ever dealt with by the mind of man."

Pierre Simon Laplace was born at Beaumont-en-Auge on March 28, 1749. He was the son of a small farmer, and at an early age began to earn his living as a teacher of mathematics in his native place. Probably the chief motive in the youth of Laplace, as in his later life, was a consuming ambition, which made an obscure provincial position intolerable to him. His opportunity of a wider sphere came in 1767, when he secured the patronage of D'Alembert, himself an able mathematician, by means of a letter dealing ingeniously with certain problems of mechanics. This fortunate introduction brought Laplace an appointment as professor of mathematics in the Military College of Paris; and from this time forward his career was one of almost uninterrupted success, achieved not always by the most strictly honourable means, yet certainly due to his extraordinary mathematical ability.

His first remarkable discovery was made with Lagrange in working out the explanation of the "long inequality" of Jupiter and Saturn, published in three papers from 1784 to 1786. His attention having been thus concentrated on the giant planet, Laplace went on to solve the riddle of his satellites, and discovered that the speed of the first satellite, added to twice the speed of the second, is equal to the speed of the third—a formula sometimes referred to as Laplace's law. The discovery of the acceleration of the moon's motion followed in 1787, and created a great sensation in the scientific world. Laplace had ascertained that the eccentricity of the earth's orbit is becoming gradually but very slightly less; and that the effect of this change is slightly to increase the mean distance of the earth from the sun. This increased distance from the sun results in a corresponding decrease of solar gravitational influence on the moon. And since the effect of the sun's gravitative pull is to enlarge the moon's orbit, any decrease in that pull results in a slight contraction of the moon's orbit, and consequently an increase in her velocity. Laplace's estimate of the rate of acceleration was not, however, altogether correct, and has been revised by later students.

Laplace's monumental work, the "Mécan-

ique Céleste," occupied most of his time between 1799 and 1825. In these labours he borrowed very freely from the works of predecessors and contemporaries, and took no trouble to acknowledge his literary and scientific indebtedness. The result is a singularly complete presentation of the entire theory. The book gains immensely in effect by this unhesitating adoption of all that had been done before; it gives an impression as if all astronomical knowledge had sprung complete from a single brain. This rather unscrupulous method would be regarded in our day as intolerable; but it must be remembered that standards in these matters were much more lax a hundred years ago. This work gave Laplace the title of "the Newton of France."

A more popular but hardly less ingenious work dated from 1796. It was called "The Exposition of the System of the World," and is chiefly remarkable because it contained the first pronouncement of the "nebular hypothesis," which has played so great a part in later astronomical speculation. The germ of the great idea is present only in very embryonic form; indeed, it is suggested merely in a note appended to the text, but Laplace leaves us in no doubt as to the value which he put upon his novel hypothesis. He was persuaded that he had penetrated into the central mystery of stellar evolution.

Laplace's earliest form of the nebular hypothesis represented the sun as already in existence, very much as it exists now. The sun was "surrounded with a vast, glowing atmosphere, extending into space out beyond the orbit of the farthest planet, and endowed with a slow rotary motion. As this atmosphere or nebula cooled, it contracted; and, as it contracted, its rotation, by a well-known mechanical law, became accelerated. At last a point arrived when centrifugal force at the equator increased beyond the power of gravity to control, and equilibrium was restored by the separation of a nebulous ring revolving in the same period as the generating mass. After a time, the ring broke up into fragments, all eventually reunited in a single revolving and rotating body. This was the first and farthest planet." Successive planets and their respective satellites were then formed in a similar manner. The theory, of course, received invaluable confirmation from the rings which surround the planet Saturn. The original germ of this nebular hypothesis came from Kant, who, though no astronomer, made two or three surprising guesses. Laplace, however, was the true originator of the theory as a serious explanation of the genesis of the solar system; and, although the idea has been much enlarged, it remains as the basis of modern speculation into the method of cosmic evolution.

Until his death, Laplace continued his studies in mathematical astronomy, and published also papers in pure mathematics. The most important of the latter was his "Analytical Theory," which appeared in 1812, dealing with the profound subject of the theory of probabilities.

Laplace received all kinds of scientific honours, but hungered also for political advancement. In this pursuit he followed the inglorious tactics of the Vicar of Bray. Having secured Napoleon's favour, he became first a member of Senate and then chancellor, and was created an officer of the Legion of Honour and ennobled. In 1814, however, when the tide had set against Napoleon, Laplace joined his opponents, and thus earned, in 1817, the title of marquis. His last years were passed at Arceuil, where he died on March 5, 1827.

WILLIAM LASSELL

A Great Discoverer of Satellites

William Lassell was born at Bolton, in Lancashire, on June 18, 1779, and at the age of sixteen was apprenticed to a Liverpool merchant for seven years. Having long had a great interest in astronomy, but unable to afford to buy instruments, he set to work laboriously to make himself a telescope. In the end, this self-taught astronomer came to rank almost with Sir William Herschel for his skill in producing telescopic reflectors. His interest in the matter had dated from early years, for it is recorded that, as a child of four years old, he used to delight in polishing lenses.

William Lassell's opportunity came in 1825, when he was able to start in business on his own account as a brewer. Soon he succeeded very well, for in 1840 he was able to build an observatory at Starfield, near Liverpool, where he set up a Newtonian reflector of his own construction. It was of nine-inch aperture, and was mounted equatorially. But, like Herschel, Lassell was always keen to produce something better than was known before. He invented a machine for polishing telescopic mirrors, with which he was able to produce a wonderfully fine surface, and in 1846 mounted in his own observatory a new telescope twenty feet in focal length, with a speculum two feet in diameter.

This also was mounted equatorially, and Lassell's reputation rests partly upon his application of equatorial mounting to the telescope. Ever since 1620, when Scheiner had attempted to connect a telescope with an axis directed to the Pole, there had been many attempts at some device which should make it possible to keep a telescope pointed to the same regions of the heavens by counteracting the rotation of the earth.

Herschel had a most elaborate and complicated mechanism of pulleys and levers for moving his thirty-foot telescope, but this required several workmen to be always in attendance. The first really satisfactory arrangement was a clockwork device applied by Fraunhofer, at Dorpat, in 1824. But Lassell's improvement, according to the testimony of Sir John Herschel, marked a new epoch in the development of that eminently British instrument the reflecting telescope. Even the largest telescopes are now mounted equatorially.

Lassell was also an observer of wonderful ability. He described an eclipse of the sun in 1842, and in the following three years he was able, with his nine-inch telescope, to follow the movements of comets long after they had been lost to all other telescopes. The twenty-foot immediately yielded most important discoveries. In the first year in which it was set up, Lassell turned it upon the newly discovered planet Neptune, and discovered a satellite revolving in the retrogade direction. Two years later he discovered the eighth satellite of Saturn, Hyperion, at the same time as it was discovered by Bond at Harvard ; and in 1851 he discovered two satellites of Uranus. Herschel had, in 1787, discovered the first two satellites of Uranus—Oberon and Titania—and in 1798 believed that he had discovered four more. But these four were really among Herschel's very rare optical illusions, as Lassell was able to prove.

In July, 1851, Lassell was in Sweden for the occasion of the total solar eclipse of that year, and during the following winter he was in Malta. In Malta he made many observations, with the twenty-foot, of the Orion nebula and of Saturn's ring. In 1861 he again went to Malta, this time taking with him a new instrument, which he had constructed in the interval. It was a magnificent reflector, thirty-seven feet in focal length, and with an aperture of four feet, its tube being composed of latticed iron, in order to provide against variations in temperature. With this instrument Lassell made a careful study of nebulæ, of many of which he made excellent drawings. He discovered six hundred nebulæ, and these he carefully catalogued.

After this second visit to Malta, Lassell moved his observatory to Maidenhead, where he lived for the rest of his life. He continued to observe, to publish his results in papers up to within a few years of the end of his life, and to attend the meetings of the Royal Astronomical Society until his death, on October 5, 1880.

URBAIN JEAN JOSEPH LEVERRIER

A Discoverer of Neptune

Urbain Jean Joseph Leverrier, who discovered, simultaneously with John Couch Adams, the planet Neptune, was born at Saint-Lo, in Normandy, on March 11, 1811. His father was a minor Government official. Leverrier was educated first at Saint-Lo, then at Caen, afterwards at the College of St. Louis, Paris, and finally at the Polytechnic School of Paris, where, in 1837, he became professor of astronomy. He was from this time altogether absorbed in mathematical studies of the movements of the planets, and soon gave evidence of astonishing mathematical abilities. Two papers, read before the Academy of Sciences in 1839, were the occasion of an introduction to Arago, and on Arago's advice he set out on the enormous task of solving the elusive problem of the erratic movements of the planet Uranus. His results appeared in a series of papers, of which the last appeared on August 31, 1846. The actual discovery of the new planet followed, on September 23 of the same year, and Leverrier achieved at one step a prodigious reputation throughout the scientific world.

The story of this wonderful mathematical discovery has been already told in our chapter on the planet Neptune. Unfortunately for the great French astronomer's reputation, its sensational interest has eclipsed his other labours, many of which were of equal if not of greater scientific value. Thus, he made most valuable researches into the sun's parallax, and fixed the orbit of several swarms of meteors.

Leverrier was appointed, in 1854, director of the Paris Observatory, in succession to Arago. He carried out certain very necessary reforms, but with such uncompromising ardour that his subordinates revolted, and in 1870 he was removed from his post for two years, to be reinstated, however, on the death of Delaunay, who had succeeded him. He died on September 23, 1877.

SIR JOSEPH NORMAN LOCKYER
The Author of the Meteoric Theory

Joseph Norman Lockyer, one of the greatest spectroscopic students of the sun and stars, was born at Rugby on May 17, 1836. From an early age he gave his whole mind to astronomy, and his rapid progress may be judged from the fact that in 1860 he read a remarkable paper on Mars to the Royal Society, of which he was in the same year elected a Fellow. The great possibilities of the spectroscope, in the study of astrophysics, had already attracted him to that field of science in which he was to win his renown. In 1866 he had devised a modification of the spectroscope for studying the flaming prominences of the sun, but the tardy makers were not able to deliver the instrument until October of 1868. In August of the same year Janssen had independently devised the same improvements, and the two astronomers, practically simultaneously, revealed the stupendous jets of blazing gas and molten metal which issue from our luminary.

With the aid of the spectroscope, Sir Norman Lockyer has made most elaborate investigations into the number of the chemical elements which are known to us on earth, and are to be found also in the sun. The inquiry was attended by great difficulty, owing to the doubtfulness of the spectroscopic record of certain elements; and of the thirty-three which he recognised some were afterwards found to be illusory. It is now fairly generally believed that certain substances exist in the sun in very different conditions from those in which they exist on earth, and that the spectra given by their light differs somewhat in the two cases.

In 1870 Sir Joseph Norman Lockyer was appointed lecturer on astronomy at the Normal School of Science at South Kensington, and received later an appointment also as professor of astronomical physics.

We have dealt very fully in an earlier chapter with Sir Norman Lockyer's meteoric hypothesis, and also with his spectroscopic work on the sun; and the facts there detailed need not be repeated. His work on the "Meteoric Hypothesis" was published in 1887, and the theory was further elaborated in a book which appeared in 1897, entitled "The Sun's Place in Nature." The fundamental idea of all this work is that "all self-luminous bodies of the celestial space are composed either of swarms of meteorites or of masses of meteoric vapour produced by heat. The heat is brought about by the condensation of meteor swarms due to gravity, the vapour being finally condensed into a solid globe." He regards nebulæ as consisting of swarms of meteors, and as being the coolest of heavenly bodies, the temperature rising through various classes to the supremely hot Sirian type, and falling again to extinction in the dark stars. The hypothesis explains all the phenomena of the heavens by meteoric collision.

Sir Norman Lockyer's many books on astronomical subjects include "Elementary Lessons in Astronomy," 1871; "Contributions to Solar Physics," 1873; "The Spectroscope and its Application," 1873; "Primer of Astronomy," 1874; "The Chemistry of the Sun," 1887; "The Meteoric Hypothesis," 1890; and "Inorganic Evolution," 1900. In 1871 he was Rede Lecturer at Cambridge; in 1874 Bakerian Lecturer to the Royal Society; and in 1874 he was awarded the Rumford medal. He was created K.C.B. in 1897.

PERCIVAL LOWELL
The Student of Mars

Professor Percival Lowell, whose interesting personality and work have already been noticed in an earlier chapter, was born in Boston on March 13, 1855, of a family celebrated in the United States for the varied accomplishments of its members. The poet James Russell Lowell was cousin of the astronomer's father. From childhood Mr. Percival Lowell was greatly attracted by the mysteries of the heavens, and after graduating at Harvard, in 1876, he began to write and lecture upon the nebular hypothesis, in which he was an ardent believer. Soon after leaving the university, however, Mr. Lowell spent some years in Japan and Korea. He had a warm regard for Japan and its people, and this feeling was fully reciprocated. He has written books and articles on Japan and Korea, and in 1883 was attached to the Korean Embassy to the United States.

Though Professor Lowell has done much varied astronomical work, it is with the fascinating and tantalising study of the planet Mars that his name is principally associated. The detailed study of the surface features of planets is, of course, a novelty within recent years, and has aroused enormous interest, perhaps because of the sinister hints which it affords with regard to the probable future of this world of ours. The Italian astronomer Schiaparelli opened up the subject of Mars, but Professor Lowell has far surpassed his master.

In the early 'nineties, especially, there was

great popular interest in Mars, owing to the discovery of the so-called "canals," which still constitute an open question of astronomy. There are so few men in the world who are competent to express an opinion at all in the matter, and their views are so hopelessly diverse, that we must be content to wait indefinitely before we shall know what the strange markings on Mars have to tell us. But scepticism is never so attractive as belief, and therefore Professor Lowell's speculations are extremely engaging. In the year 1894 he set up his wonderful observatory at Flagstaff, Arizona, with the express purpose of studying the planet Mars under the best possible conditions. Professor Lowell is convinced that the site is the most important consideration in planning an observatory, and that clear air is worth more than powerful lenses.

The great series of observations on Mars was begun in 1895, and in the end of that year Mr. Lowell was able to publish his views in a volume entitled "Mars." He follows Schiaparelli in regarding the "canals" as actual waterways, lined on each side by areas of vegetation due to irrigation, and believes with Professor Pickering that the lines which we see on the surface of the planet are these strips of fertile country, and not the waterways themselves. The canals are supposed to distribute over the face of the planet the water which is supplied by the seasonal melting of the Polar ice-caps.

Professor Lowell has also observed Mercury and Venus with conspicuous success, discovering that, contrary to what was formerly supposed, each of these planets rotates once on its own axis during the period in which it travels once round the sun. He thus demonstrated that, as the moon turns always the same face to the earth, so both Venus and Mercury always turn the same face to the sun. Mr. Lowell was appointed, in 1902, professor of astronomy at the Massachusetts Institute of Technology, and his first course of lectures, which was brilliantly succeessful, has been published in the volume "The Solar System," 1903.

SIMON NEWCOMB

A Believer in a Limited Universe

Simon Newcomb was a Canadian, born at Wallace, Nova Scotia, on March 12, 1835. He was intended for a farmer, but soon found he had no taste for agriculture, so was sent to his grandfather in New Brunswick to learn the trade of a carpenter. Here he fell in with a herbalist quack doctor, to whom he was persuaded to apprentice himself, but after two years, in which he learned nothing, he ran away to his father, who was now settled in New England. After some time spent in teaching, he at last got a post more suited to his remarkable mathematical abilities—namely, that of computer on the "American Nautical Almanac." He graduated in 1858 at the Lawrence Scientific School at Harvard, and continued to make a special study of mathematics until, in 1860, he was chosen to accompany a party sent to Saskatchewan for the eclipse of that year.

In 1861 Newcomb became professor of mathematics in the United States Navy,

SIMON NEWCOMB

and astronomer in charge of the Naval Observatory. In 1877, after refusing the position of director of the Harvard College Observatory, he became superintendent of the "Nautical Almanac." Telescopic observation of the heavens was never his real vocation; he was primarily a mathematician, and his most important researches all belonged to the department of mathematical astronomy. He retained his position at the head of the "Nautical Almanac" for twenty years, and retired only on reaching the age limit in 1897. In 1884 he became professor of mathematics and astronomy in the Johns Hopkins University, Baltimore. He received many honours

from scientific societies before his death, at Washington, on July 11, 1909. He had been made a rear-admiral of the United States in 1906.

Professor Newcomb achieved a well-deserved reputation for his admirable work in computing the orbits of all the planets, for his studies on the orbital movements of the moon, and especially for his investigations of the movements of the "fixed stars," which are now known to be so very far from fixed. His laborious researches into the motions of the stars led him to the conclusion that the normal velocity of our sidereal system is twenty-five miles per second; and he therefore considered such stars as 1830 Groombridge, with its velocity of 200 miles in a second, to be a "runaway" star, and a mere passing visitor.

Newcomb's work went far to establish the very generally accepted belief that the universe is limited in extent, and that its boundary is indefinite and irregular. By means of a very elaborate process of counting the stars which are visible, or, rather, can be photographed, in every field of the heavens he showed that the darker regions of the Milky Way are only slightly richer in stars than other parts of the heavens, while the bright areas are between sixty and one hundred per cent. richer than the dark areas, and thus inferred the existence of a distinct unity of plan in the structure of the visible universe.

Professor Newcomb published several books on astronomical subjects, including "Popular Astronomy," 1878; "The Stars," 1901; "Astronomy for Everybody," 1903; and an autobiography under the title of "The Reminiscences of an Astronomer," 1903; and a "Compendium of Spherical Astronomy" in 1906. His mind, as is more characteristic of Americans than of Britons, had a wide range of interests, and he was known also as a writer on political economy, and even as a novelist.

GIUSEPPE PIAZZI
Discoverer of the First Asteroid

Giuseppe Piazzi, the famous Sicilian astronomer, was born on July 16, 1746, at Ponte, in Italy. A youth of profound and varied learning, he was professed a monk in the Theatine order, and became well known at first as a teacher of philosophy and theology, but in 1780, at the age of thirty-four, was appointed professor of mathematics in the University of Palermo. From mathematics he passed more and more to astronomical studies, and travelled in order to acquire practical experience of the methods which obtained in contemporary observatories. Under the patronage of Prince Caramanico, viceroy of Sicily, he set up in 1791 an observatory, which was built upon one of the towers of the viceroy's palace. The position proved extremely advantageous for telescopic observations. Piazzi's earliest labours were directed to the compilation of a catalogue of stars, with their positions defined with the most sedulous precision. Such a work was greatly needed. The already existing catalogues of stars included a large number of celestial objects, but the positions which were given for them were only approximately correct; and a great deal of calculation was still necessary in order to allow for refraction, precession, and other qualifying factors. Piazzi completed two catalogues, published in 1803 and 1814. These included about 7000 stars, and were a great advance on anything previously attained, though they were destined to be superseded by Bessel's "Fundamenta Astronomiæ," and other later works of the same nature.

While engaged upon his first catalogue, Piazzi came upon a moving body which he interpreted as an unusually definite comet without tail or coma, but which presently turned out to be a new planet, and was, in fact, the first of the many asteroids which have since been discovered. Piazzi detected this body on January 1, 1801, but after watching it for some time he fell ill, and it was lost; and it was only rediscovered a year later by means of the calculations of the prodigious mathematician Gauss. Piazzi named this first-known asteroid "Ceres," in honour of Sicily.

Piazzi accomplished a great variety of most valuable work at Palermo. Thus, he was the first to notice, in 1792, the large proper motion of 61 Cygni, and to point out that this probably indicated comparative nearness to our solar system. Again, he expended a vast amount of labour in searching for stellar parallaxes, and claimed to have discovered these apparent movements, of very considerable size, in the case of Sirius, Procyon, Vega, and Aldebaran; but it has since been shown that his results were actually due to the imperfections of his appliances. Nevertheless, in the great vertical circle made for him by Ramsden in 1789, he possessed the finest instrument of the time for determining celestial positions. Piazzi died at Naples on July 22, 1826.

EDWARD CHARLES PICKERING

Measurer of the Brightness of the Stars

Edward Charles Pickering, one of the greatest of American astronomers, was born in Boston, Massachusetts, on July 19, 1846. He was greatly interested in science from his earliest years, and as a boy he constructed a telescope, tailless kite, camera obscura, and an electrical machine. He also devised a perpetual calendar and a planisphere, and was an expert amateur photographer in the days when there were not even many professionals.

His school education was unfortunately almost entirely classical, but in 1862 he entered the Lawrence Scientific School of Harvard University, studying especially mathematics, chemistry, physiology, and mineralogy, and graduating with high honours. He was at once offered a position in the school as teacher of mathematics; in 1867 he was promoted to a better appointment in the Massachusetts Institute of Technology, and was soon after made Thayer Professor of Physics. He organised and developed the first physical laboratory in the United States, and prepared a text-book, entitled "Physical Manipulation," which remained for forty years the chief manual on the subject. Among his practical inventions was a telephone receiver having a flexible diaphragm, constructed in 1870; this was exhibited before the American Association, and proved an effective instrument for speech at a distance.

In 1876 Professor Pickering was appointed director of the Astronomical Observatory of Harvard University, and still holds this position. His first, and in some respects the most notable, work was in stellar photometry. For this purpose he devised the "meridian photometer," an instrument so constructed as to show at the same time a direct image of the star to be measured, and the reflected image of the Pole Star, which he took as a standard, second-magnitude star. One of these images having been modified by polarisation until the images of the two stars appear of precisely equal brilliancy, and the degree to which the former had been modified having been read off on a scale, the observer can see at a glance the difference of magnitude, and thus a precise measure of brilliancy is obtained. Many thousands of stars were measured with this instrument. Professor Pickering then made another and larger photometer on the same principle, and with it measured the brilliancy of many more stars. Further, one of these instruments was sent out to the southern hemisphere, and similar measures were made of the southern stars.

In 1886 increased means permitted a great extension of the work of the observatory. A station was established in Arequipa, Peru, and was equipped with instruments like those in Cambridge. Since then the principal researches undertaken at Harvard have been made to include all portions of the sky, from the North Pole to the South Pole. In 1890 Professor Pickering published his catalogue of stellar spectra, a work which he had undertaken as a memorial to Professor Draper.

It includes investigations of the spectra of 10,351 stars, covering the northern hemisphere and part of the southern. Ample material is thus provided for researches into the nature and distribution of stars; and Professor Pickering himself at once proceeded to examine its records in order to ascertain the distribution of the stars of the various types. He found that while most classes are fairly equally distributed, stars of the first, or "Orion," type cluster near the Milky Way. Professor Pickering arrived at the conclusion that the Milky Way is "a distinct cluster of stars, to which, from its composition and age, the sun does not seem to belong."

With regard to the evolutionary history of the stars, a problem to which he has given much attention, Professor Pickering agrees with Vogel. "In general," he concludes, "it may be stated that, with a few exceptions, all the stars may be arranged in a sequence, beginning with planetary nebulæ, passing through the bright-line stars to the Orion stars, thence to the first-type stars, and by insensible changes to the second and third type stars. The evidence that the same plan governs the constitution of all parts of the universe is thus conclusive."

It was in the course of the photometry of stellar spectra for his famous catalogue that Professor Pickering made a most important discovery—namely, the discovery of spectroscopic binaries. The phenomenon was actually first seen by a lady assistant at the Observatory, Miss A. C. Maury. It was confirmed shortly afterwards by Professor Vogel's similar discovery at Potsdam, and a most fruitful branch of research was thus opened up to astronomy.

Meanwhile, Professor Pickering was also carrying out a very ambitious scheme in astronomical photography, on a larger scale and on a different plan from any in use elsewhere. More than two hundred thousand

overlapping photographs have been obtained, covering the entire sky many times; and this unique collection furnishes the only available record of the principal events in the stellar universe occurring during the last quarter of a century. By means of this great sky-chart many new and temporary stars have been discovered, including the new stars of 1887 in Perseus, of 1893 in Norma, of 1895 in Argo, of 1895 in Centaurus, of 1898 in Sagittarius, and of 1900 in Aquila.

Professor Pickering has also given much attention to variable stars, especially to short-period variables of the Algol type; and he was the first to suggest the eclipsing-satellite theory of the latter, a conjecture which has now been fully established by spectroscopic investigations. He has also made photometric observations of the planets, asteroids, and satellites, and has by this means determined the sizes of many of the asteroids, and of the satellites of Mars.

Among the honours conferred on Professor Pickering are the membership of the Royal Society of London, the French Academy of Sciences, the Royal Prussian Society, the Imperial Academy of St. Petersburg, and the Academia dei Lincei; he has received many honorary degrees and medals of learned societies, and is the only living American who possesses the Prussian "Ordre pour le mérite." He has unquestionably made an indelible mark in the history of astronomy.

RICHARD ANTHONY PROCTOR
Popular Interpreter of Astronomy

Richard Anthony Proctor was born at Chelsea on March 23, 1837. His father, a well-to-do solicitor, died in 1850, leaving his family impoverished for years by a long lawsuit, so that Richard was obliged to take a post, in 1854, as clerk in a London bank. After a time, however, the family fortunes somewhat recovered, and Proctor was able to proceed to the university. With the aid of a scholarship, he entered St. John's College, Cambridge, in 1855, and plunged with enthusiasm into the studies of mathematics and theology. In his second year, however, he married, and his work, as was only to be expected, suffered in consequence, so that, instead of fulfilling the brilliant expectations which were entertained for him, he graduated only as twenty-third wrangler.

On leaving the university, Proctor read for the Bar, but soon became tired of the law, preferring to give his attention to science. His first essay in astronomical writing, in the form of an article on double stars, appeared in the "Cornhill," in 1865. This was followed by a short but very notable work on "Saturn and his System," which brought his name to the notice of the scientific world.

New financial reverses, which deprived him of his income, and threw him back upon his own efforts for maintenance, made it imperative to devote himself to literary hackwork, and from 1866 he toiled incessantly for five years without so much as a day's holiday. His articles were chiefly on astronomical subjects, but included a variety of others. It was weary, uphill work at first, for he had not made his name, and had difficulty in getting work. He asserted that he would willingly have turned to stone-breaking, or any other form of hard, honest, but unscientific labour, if a modest competence had been offered him,

Gradually, however, his work became known and valued. He was assisted by friends to publish several books, and in 1868 his "Half-Hours with a Telescope" was written for publishers who paid him £25 for it. It was the first of his works to acquire that wide popularity which many of his later writings enjoyed, and before he died he had seen twenty editions of this book.

It was not until 1873 that Proctor began lecturing in astronomy. He visited the United States and Australia, and in both countries achieved immediate and enormous success on the public platform. In these lectures, as in his writings, his wonderful power of lucid exposition made his work extraordinarily effective in popularising astronomy, and in correcting prevalent errors by showing their unscientific basis.

Proctor's wife died in 1879, and two years later he married again. His second wife was a widow living at St. Joseph, Missouri. Proctor consequently went to live there, and remained in Missouri until 1887, when he moved with his family to Orange Lake, Florida. He died in New York on September 12, 1888, while on a business journey to England. He had all this time retained an intimate connection with England. He wrote papers for the "Monthly Notices" of the Royal Astronomical Society, and in 1881 founded the weekly scientific paper "Knowledge," published in London, which has since become a monthly. He continued to issue books, chiefly on astronomical subjects, but sometimes on topics of more general interest. During his lifetime he published as many as fifty-seven volumes,

and at his death left one unfinished, "The New and Old Astronomy," which was edited and completed by Ranyard in 1892, Among the more popular of his books are "Other Worlds than Ours," "Star Atlas," "Elementary Astronomy," "The Orbs Around Us," "Our Place Among Infinities," "The Sun," and "Transits of Venus."

Proctor was not, however, by any means a mere exponent of results which had already been arrived at, although perhaps his most important services to science lay in that direction. He pursued researches on his own account, and some of these have been of considerable value. His investigations into the rotation period of the planet Mars resulted in a determination which has been said to be of a precision unapproached in the case of any other heavenly body except that of the earth itself. The period was worked out by Proctor to minute fractions of a second.

His researches into the constitution of the Milky Way elucidated the independent nature of this structure. It is to Proctor, as the late Miss Agnes Clerke remarks, that we owe the discovery that "the stars forming the galactic stream are not only situated more closely together, but are also really, as well as apparently, of smaller dimensions than the lucid orbs studding our skies. By the laborious process of isographically charting the whole of Argelander's 324,000 stars, he made it clear, in 1871, that the brighter stars show, in their distribution, a detailed relationship to the complex branchings of the Milky Way, avoiding, to a marked extent, its vacuities, and thronging its denser convolutions. It follows that they must be actually intermingled with them. So that, for every triton sun, there are doubtless swarms of minnows."

Another amazing phenomenon, brought to light by Proctor's indefatigable charting—this time by the charting of stellar proper motions—was what he himself called "star-drift." Large groups of stars, often at great distances apart, and with no other apparent connection, were found to progress together at the same rate and in the same direction across the sky. The reality of this common drift has been proved by the spectroscope. The immensity of the system revealed by this common star-drift is quite unthinkable, the stars being, in most cases, infinitely remote, and consequently at enormous distances from one another, yet they are found to be united by some mysterious tie.

These important discoveries show how far Proctor's astronomical work was from being merely popular or expository. They prove him to have been a profound as well as an exceptionally lucid thinker, and to have penetrated far into the secrets of the celestial system which he did so much to elucidate for others.

PTOLEMY

Who Ruled Astronomy for Fourteen Centuries

Claudius Ptolemæus, the great expounder and perfecter of the older geocentric system of astronomy, lived in the second century of our era. Almost nothing is known of his life, except that he was a native of Alexandria, and that he made observations as early as 127 A.D. and as late as the year 150.

Besides being the greatest astronomer of his day, Ptolemy became illustrious for his work in pure mathematics, which marks the beginning of the study of trigonometry, and still remains the foundation of that science. He was also an eminent geographer, and in this subject, as well as in his astronomical teaching, was known to Roger Bacon, who carried forward his geographical theories after eleven centuries.

It was by his astronomical system, however, that Ptolemy rendered his greatest service to science, and it is with the treatise relating to this system that his name will be immemorially connected. The modern progress of knowledge, which has gained so much by the refutation of the system expounded in the "Almagest," has embodied the record of this work in the history of its forward march. In the "Almagest," or "Syntaxis," Ptolemy reviews the theory of astronomy as far as it had been carried by Hipparchus, whose theories he improved and corrected in many directions, notably with regard to the lunar theory and the planets. The theory of the sun, on the other hand, he left as Hipparchus had formulated it; and the consequence is that his tables gave very erroneous values, inasmuch as the theory of Hipparchus had made the mean motion of the sun too small, and the error in the course of the intervening three centuries had grown to be very considerable.

Ptolemy adopted the system of epicycles and eccentrics used by his predecessors, using it, indeed, as a mere geometrical device to explain the observed motions, and not professing to give thereby a representation of the actual system of the universe. He accepted as a working basis the views generally held at the time with regard to the construction of the world, and endeavoured to bring together into one

complete and adequate theory all that was known of astronomical science. Thus, his ground-plan consisted of a heavenly sphere carrying the fixed stars and turning upon a fixed axis, with the earth, an infinitesimally small body in comparison with the heavens, at its centre.

Ptolemy denied any motion, either of rotation or translation, to the earth, maintaining that, if there were any such motion, it would be in proportion to the earth's great mass, and that consequently animals and other objects would be thrown outwards by centrifugal force, and would be left behind in space! The arrangement of the planets, from the earth outwards, was in the following order: Moon, Mercury, Venus, Sun, Mars, Jupiter, Saturn. The sun and moon were usually regarded as of the number of the seven planets, but Ptolemy does, in fact, in considering the motions of the planets, refer to them as "the five wandering stars," and distinguishes them from the sun and moon.

Hipparchus had left his theory of the moon incompletely developed, confessing that there remained certain inequalities for which his calculations failed to account, but leaving the nature and explanation of these inequalities to future investigation. Nothing was added to his ancient work, however, until Ptolemy attacked the problem, and at last succeeded, by means of a combination of epicycle and eccentric, in formulating a theory which allowed of the determination of the moon's apparent place with an accuracy as close as was practically necessary in his time, when instrumental efficiency did not make it possible to ascertain the positions of heavenly bodies within a possible error of 10′.

With the same care and mathematical ingenuity, Ptolemy corrected the theory of each of the planets. The motions of these bodies presented great difficulties, which is not surprising when we consider that the complicated observed motions had to be explained in the light of an earth-centred universe, and by means of combinations of circular motions. Yet Ptolemy achieved considerable success in this task. As Mr. Dreyer says: "That the system as a whole deserves our admiration as a ready means of constructing tables of the movements of sun, moon, and planets cannot be denied. Nearly in every detail (except the variations of distance of the moon) it represented geometrically these movements almost as closely as the simple instruments then in use enabled observers to follow them, and it is a lasting monument to the great mathematical minds by whom it was gradually developed. It appears from many statements, not only of Ptolemy himself, but also of his commentators, that they merely considered the numerous circles as a convenient means of calculating the positions of the planets."

Ptolemy was acquainted with the phenomenon of precession, discovered by Hipparchus, and corrected the value found for it by the latter to the roughly approximate and convenient figure of 36″ a year, or one degree in a hundred years. But it was not until centuries later that the true value of Ptolemy's work came to be appreciated. In the intervening centuries—that is, after a short period of fame and commentaries—a narrow-minded Christianity swept away all the vast treasures of pagan thought, and astronomy began to be fettered by a pseudo-scientific and too literal interpretation of Scripture.

Until the seventh century, the achievements which had been made in astronomical science by the ancients may be said to have been practically non-existent for Christian Europe. The earth was again regarded as flat, with the heavens spread tent-like over it, while the setting sun passed behind a northern barrier or wall. The "waters above the firmament" were a peculiarly tyrannical feature of early mediæval cosmology, and constantly appear as an important agent in qualifying the heat of sun, moon, and stars, or even as a provision for the future final extinction of these fiery bodies. Occasionally a more enlightened teacher, such as Isidore of Seville in the sixth century, would venture to put forward tentatively, as "a doctrine which has been taught," the theory of a spherical earth, or of a spherical revolving heaven. By the next century these opinions had considerably gained ground, and are boldly stated by the Venerable Bede in his treatise "Of the Nature of Things." Bede returns to the spherical earth, the seven planets (including, of course, the sun and moon) revolving about it, and to the fact of the sun being much larger than the earth; he adheres, however, to the inevitable waters above the firmament, in spite of having asserted the sphericity of the heavens.

From this time onward we find a gradually increasing acquaintance with the works of the Greeks, and at last, in the thirteenth century, a clear exposition by Thomas Aquinas, following Ptolemy in many points, of Aristotle's book on the heavens and the

earth. Roger Bacon in the same century also knew and taught the Ptolemaic theory, with great independence of thought. From this time onward, consequently, we find a growing discontent with the spoon-fed doctrines which took the place of science; and one of the earliest indications of this spirit was a desire for first-hand acquaintance with the writings of Ptolemy himself. The spirit of ancient Greece sent a breath of new life over the mind of Europe, and astronomy benefited, as much as any science, from the fresh spirit of humanism and youthful intellectual force. The extraordinary insight shown in the work of Nicolaus de Cusa, who wrote in the first part of the fifteenth century on "learned ignorance," finds its complement in the ardour for correct knowledge which led to the earnest study of Ptolemy, and at last to the publication of his original works. The first Latin edition was published in 1515, but not from the original; a translation from this latter first appeared in Paris in 1528, while the Greek original was printed at Basle in 1538. Five years later the "De Revolutionibus" of Copernicus appeared, and Ptolemy's long reign was at an end.

GEORGE WILLIS RITCHEY
Prince of Astronomical Instrument Makers

George Willis Ritchey was born at Tuppers Plains, in Ontario, Canada, on December 31, 1864. He studied at the University of Cincinnati, and in 1888 was appointed instructor at the Chicago Manual Training School. This position he held until 1896, when he became optician to the great Yerkes Observatory. In 1899 he was promoted to the position of superintendent of instrumental construction for the observatory, and continued to supervise this department for five years. He then spent four years at the University of Chicago, where he taught practical astronomy, and from 1905 until 1909 he was in charge of the Solar Observatory of the Carnegie Institute, as astronomer, and again as superintendent of instrumental construction.

When the directors of the Mount Wilson Observatory, California, decided in 1909 to build a 100-inch reflecting telescope, they commissioned Dr. Ritchey to supervise its construction. Since early in that year, consequently, his time has been chiefly devoted to this ambitious undertaking. He at once came over to Europe in order to study the latest details of construction, and has often attended the meetings of the Royal Astronomical Society, of which he was elected in 1904 a foreign associate. Among other instrumental advances of supreme importance to the progress of astronomy which we owe to Dr. Ritchey, his many photographic devices and improvements take a high rank. In 1910 he astonished the scientific world with three photographs of spiral nebulæ of surpassing excellence, in which the most remarkable details of their structure were clearly brought out as had never been done before. In one case the spirals appear broken up into soft, star-like condensations, like nebulous stars. He has also secured wonderful photographs of the Great Nebula in Andromeda, of the Ring Nebula in Lyra, of the Crab Nebula, and of others, which provide an indispensable aid to the further investigation of the construction of nebula. His photographs have done an enormous amount for this study; even a cursory examination of them revealed their diversities, so that, while in some the spirals are broken up into "nebulous stars," in others they are apparently smooth. One of the spiral nebulæ was found to show more than a thousand of these star-like condensations. In the Andromeda Nebula, as revealed by these admirable photographs, the central parts appear to be regular, with complicated dark rifts, and the spiral extends practically to the nucleus, but the outer branches, on the other hand, are seen to contain great numbers of nebulous stars.

Dr. Ritchey has made great improvements to the camera, especially with regard to focussing. He uses two guiding eye-pieces, one on each side of the centre, in order to allow for any possible slight rotation of the field, and by a special device of his own the plate-carrier may be removed and replaced with absolute accuracy every half-hour, thus allowing of continual refocussing.

LORD ROSSE
Builder of a Giant Telescope

William Parsons, third Earl of Rosse, is chiefly known as the constructor of the famous giant Parsonstown Reflector. His labours in improving the telescope entitle him to rank with Sir William Herschel among the very first of those who have helped to produce the instrumental perfection upon which the science of astronomy so largely depends. Born at York on June 17, 1800, William Parsons was the son of the second Earl of Rosse. From 1807 he bore the title of Lord Oxmantown, until, on his father's death in 1841, he became third Earl of Rosse. From Trinity

College, Dublin, he passed to Oxford, and graduated in the first class in mathematics in 1822. Although a man with many public claims on his time and energies, none of which he ever neglected, he yet succeeded in pursuing the study of science, and in carrying out his early design of constructing a telescope which should reach the limits of attainable power.

The difficulties with which he had to contend were enormous, and his success bears witness to the qualities of mind and character which enabled him to surmount them all. He had to discover the whole art of casting and polishing telescopic reflectors by his own unaided efforts. He had not even skilled mechanics to assist him, but trained the cottagers on his estate to carry out the difficult operations which were required. Much was owing to their loyal service.

He began experimenting in the composition of speculum-metal, at his father's seat, Birr Castle, Parsonstown, King's County, in 1827, but it was not until twelve years later that he succeeded, after innumerable failures, in the casting of a three-foot speculum. The precision required in this process is extraordinary, as an exceedingly minute error is sufficient altogether to destroy the efficiency of the instrument. Sir John Herschel tells us that " the total thickness to be abraded from the edge of a spherical speculum 48 inches in diameter and 40 feet focus, to convert it into a paraboloid, which is the required figure, is less than one twenty-thousandth of an inch." Having, at last, in 1839, succeeded in casting his metal into a three-foot speculum, and mounting it as a telescopic reflector, Lord Oxmantown published all the details of its construction in a paper communicated to the Royal Society, thus conferring upon optical science a benefit even greater than the actual accomplishment of the work.

Lord Rosse now proceeded in 1842 to construct a reflector of enormous size. It measured six feet in diameter, was of fifty-four feet focal length, and weighed four tons. The tube which held it was fifty-eight feet long and of seven feet diameter. It was slung in chains between two stone piers, each seventy feet long and about fifty feet high, placed about twenty-three feet apart. The great telescope was hung with such perfect balance that, although weighing fifteen tons, it was moved with the greatest ease by means of a windlass. It gave a great vertical range from near the horizon to the pole, but its horizontal range was necessarily limited by the supporting piers, and only gave about ten degrees on each side of the meridian. It was mounted and ready for use in February, 1845.

The light-grasp of this enormous reflector astonished all beholders, and its powerful magnifying qualities were productive of most important results. The study of nebulæ was immediately carried forward in an unprecedented degree. Many hitherto unresolvable nebulæ were resolved by it into clusters of stars, but more important still were the structural details of many classes of nebulæ which it revealed. The difference between planetary and annular nebulæ was annulled by the discovery of a ring-like structure in the planetaries, and the important class of spiral nebulæ was discovered. The resolution of a great number of nebulæ into clusters of stars by the Parsonstown telescope led many too hastily to the conclusion that all nebulæ are ultimately of that kind, and to deny the existence of the " luminous fluid " as a separate formation. Lord Rosse himself was more careful, and refused to acquiesce in this conclusion. Later researches have, of course, justified his caution, by proving beyond a doubt the existence of an irresolvable class of nebulæ.

The details of further work in order to the perfection of his instrument were communicated to the Royal Society in 1861, in a paper " On the construction of specula of six feet aperture, and a selection from the observations of nebulæ made with them." Thus Lord Rosse placed all his years of experimental labours at the disposal of future constructors of telescopes.

Innumerable honours were conferred upon Lord Rosse for his brilliant achievements, including honorary degrees of many universities, foreign titles, and university chancellorships.

Notwithstanding all his wonderful scientific and optical labours, the duties of territorial and of public life were at all times most conscientiously carried out. While still an undergraduate at Oxford, he was returned as member of Parliament for his home constituency of King's County, and continued to represent it until 1834, when he resigned his seat in order to secure more leisure for scientific and philosophical pursuits. From 1845 until his death he sat in the House of Lords as an Irish Representative Peer, taking, as a rule, no part in debate, but doing much unostentatious service in committee. His hospitality was typical of the best traditions of the Irish character.

His devotion to his tenants, towards whom his position was analogous to that of a feudal lord, absorbed much of his time, and often also of his means. During the time of serious famine which occurred in 1846-7 Lord Rosse gave away to his starving people practically the whole of his revenues. His courage was as great as his generosity; for during this same time, when the passions of the people were inflamed by their sufferings to animal savagery, he was continually active in the work of suppressing the murderous associations which were formed, although this conduct placed him in constant danger of his life. His profound and intimate acquaintance with his country and its people is reflected in several books on the subject.

Lord Rosse married in 1836, and had four sons. He died at Monkstown, County Dublin, on October 31, 1867, after a long and painful illness.

GIOVANNI VIRGINIO SCHIAPARELLI
Explorer of Mars

The great Italian astronomer Giovanni Virginio Schiaparelli was born at Savigliano, in Piedmont, on March 14, 1835. Proceeding at the age of sixteen to the University of Turin, he studied mathematics, and, after three years, graduated in engineering and architecture. But from that time onward he determined to follow out his real interest, which lay in the direction of astronomy, and from 1857 to 1859 attended Encke's lectures in Berlin. He then went on to the observatory at Pulkowa, where he became an assistant under the two eminent Struves, but remained here only for a year, being recalled to Italy in 1860 to become assistant at the Brera Observatory in Milan. His reputation was quickly made by his discovery, in the following year, of the asteroid Hesperia; and on the death of Carlini, in 1862, he was appointed director of the observatory. This post he held for thirty-eight years, for he retired from it only in 1900 on account of ill-health. All Schiaparelli's great mass of work was therefore done at the Brera Observatory. The most illustrious of his researches have been those which established the relation between comets and meteors, and his researches on the planet Mars; but of almost equal importance are his discoveries with regard to the rotation periods of Mercury and Venus, and his investigations into the distribution of the stars.

Schiaparelli's earlier cosmical generalisations were the results of a protracted study of meteors. These conclusions were communicated in five letters, published in 1866, in the "Bullettino" of the Roman Observatory. In these letters Schiaparelli showed that meteors, like comets, have a velocity far exceeding that of the earth; that they travel to immeasurably greater distances from the sun; that they are foreign bodies, drawn into the solar system from interstellar space by the sun's attraction, and sometimes captured as permanent members by planetary gravitation; and finally, in the last letter, the momentous conclusion was reached that the orbit of the Perseids corresponds with the orbit of the bright comet of 1862, and that the comet is but a larger member of the meteor swarm. Other examples were soon discovered, and, in 1867, Schiaparelli was able to formulate his theory of comets. According to him, there exist in space masses of celestial matter—"cosmical clouds"—fragments of which enter our system under the attractive force of the sun, and sweep across our skies in the form of comets. The theory of meteors, as the product of the dissolution of comets, was fully treated in Schiaparelli's famous book "Of Falling Stars," published in 1873, and pronounced by Sir Norman Lockyer to be one of the greatest astronomical writings of the nineteenth century.

In 1877 Schiaparelli began his investigations of the planet Mars, and his searching scrutiny was carried on at every succeeding opposition of the planet. These observations mark an entirely new epoch in the study of Mars. At the opposition of 1877 Schiaparelli discovered the so-called "canals," which he recognised as showing exactly the same appearance during the next opposition of 1879. But in 1881 about twenty of these canals were seen to be double, inasmuch as a parallel line, at a distance of two or three hundred miles, ran alongside the line originally observed.

An exquisitely clear atmosphere is necessary in order to make these canals visible, and for many years Schiaparelli seems to have been alone in his detection of them. Doubt was for some time thrown upon his discoveries, but in 1866 the canals were observed by Perrotin at Nice, and they have since been seen at Lick, at Arequipa, and at other advantageously situated observatories. The observation of Mars continued to occupy Schiaparelli at every opposition, but in 1890 failing eyesight deprived him of this delight. He

then, however, formulated the conclusions to which his continued researches had led him. The Polar caps, he believes, are true ice and snow, the reddish-ochre portions are land, and the blue-green "seas" and the "canals" are truly water, the canals being waterways, not impossibly the construction of intelligent beings. These waterways are lined on each side by strips of vegetation. Schiaparelli compares the climate of Mars to that of a clear day on a high mountain.

From Mars, Schiaparelli proceeded to a protracted study of our inner planetary neighbours, Mercury and Venus, with similar startling results in the case of each. Each of these planets had been formerly supposed to have a rotation period of about twenty-four hours; but Schiaparelli, by observing the planets over a considerable number of years, became convinced that in each case the rotation-period corresponds to the period of revolution in exactly the same manner as in the case of the moon's motion about the earth. These results were announced in 1889 and 1890 respectively; they were questioned at first, but have since been fully confirmed.

His next important contribution, in 1889, was a paper on the apparent distribution of stars visible to the naked eye, proving conclusively Herschel's theory of the crowding of these stars towards the plane of the Milky Way. This work was carried out with the same care and patience which Schiaparelli gave to everything he undertook. The conclusion he reached was demonstrated by a series of charts accompanying the paper.

Double stars also were a favourite study of his. He measured the orbits of a large number, and his results have given him a distinguished name among investigators of binary systems. In addition to the natural gift of keen eyesight, and to his innate characteristics of perseverance, exactness, and a fastidious love of truth, Schiaparelli owed not a little of his supreme success as an observer to the unfailing resolution with which he abstained from anything that might impair steadiness or clearness of vision, as, for instance, from alcohol, narcotics, and coffee.

Schiaparelli retired in 1900 from the direction of the Brera Observatory, and was succeeded by Celoria. He continued, however, to pursue his studies in seclusion, and to write books on astronomical subjects and on kindred interests. He died at Milan on July 4, 1910. His biographer has well said: "His devotion to astronomy, his singularly accurate observations, and his wonderful discoveries have secured for him an exalted position among the greatest astronomers of modern times."

HUGO SEELIGER

Student of the Construction of the Heavens

Professor Hugo Seeliger, an eminent German astronomer, was born at Bielitz-Biala, in Silesia, on September 23, 1849. He attended first the University of Heidelberg, and from 1868 that of Leipzig, graduating at Leipzig in 1871, his thesis for the doctorate being on double stars. After a period of honorary assistance in the Leipzig Observatory, Seeliger obtained a position in 1873 at the Bonn Observatory under Argelander, and gained valuable experience in practical astronomy by his work on the famous Catalogue. He took charge of the expedition which went from Bonn to the Auckland Islands, to observe the transit of Venus of 1874. Three years later Seeliger gave up observation for teaching, becoming an authorised tutor in astronomy in Bonn University, but was not long in returning to practical work. In 1881 he was made director of the Gotha Observatory, and in the following year was appointed to the charge of the Royal Observatory at Munich. At the same time he became professor of astronomy in Munich University. He proceeded at once to turn to profit the experience gained under Argelander; and the Munich Catalogue of 13,200 stars was drawn up and published under his direction. The numerous observations of Dr. John Lamont, a Scotsman who had been director of Munich Observatory some twenty or thirty years earlier, were reduced by Seeliger into a catalogue of 30,082 stars.

The most famous of Seeliger's researches have been in connection with Saturn's rings, with temporary stars, but, above all, with the distribution of stars and the construction of the heavens. His theory of Saturn's rings was put forward in 1888. It was not so much a new theory as a strong and carefully grounded confirmation of ideas which had been gradually taking form. Laplace had regarded the rings as solid bodies. Their solidity was first shown to be impossible by the younger Bond, who postulated a fluid condition. But the first real light was thrown upon the problem by James Clerk Maxwell in 1857, in a treatise proving that neither solid nor fluid rings could be permanent, and that their only possible composition was by an aggregation of separate

particles. Seeliger develops the theory of the meteoric constitution of the rings. In a paper published in 1888 he demonstrated that the unchanging lustre of the outer rings, no matter what the angle of illumination might be, is an indubitable proof of their meteoric constitution. He further demonstrated that the dusky ring is formed of bodies more thinly strewn, and consequently reflecting much less light. The great difficulty with which this theory of the dusky ring had always been met—the fact that it shows as a dense, dark shading against the body of Saturn—he explains by showing that the dark band is due to the numerous shadows of the small bodies in transit across the globe of the planet. Spectroscopic investigation has since confirmed Seeliger's theory.

The advent of the new star in Auriga led to Seeliger's exposition, in 1892, of his theory of temporary stars. According to him, the brief glory is due to the passage of a dark body through the nebulous matter which abounds in the celestial spaces, and its consequent incandescence.

Professor Seeliger's studies in the distribution of stars are undoubtedly the most thorough which have ever been attempted. The work was pursued in a most systematic and highly detailed manner, and was based upon all the important star-catalogues and measurements of distribution. For purposes of accurate comparison, Seeliger divided the sky into nine zones, each of them twenty degrees wide, and all parallel to the circle of the Milky Way. His examination demonstrated the real, gradual increase in the number of stars, from each of the galactic Poles, to the Milky Way. "The Milky Way is no mere local phenomenon, but is closely connected with the entire constitution of our stellar system."

These researches of Professor Seeliger constitute a great advance on all that had previously been done towards the investigation of the construction of the heavens. In themselves, apart from all his other valuable work, they entitle him to rank among the foremost of living astronomers.

CHARLES PIAZZI SMYTH
A Star-Gazer at High Levels

Charles Piazzi Smyth, so named after the great Sicilian astronomer Piazzi, was born at Naples on January 3, 1819, the son of Admiral William Henry Smyth. After some years at Bedford Grammar School, he was sent, at the age of sixteen, to the Royal Observatory at the Cape of Good Hope, where he became an assistant, and learned the ordinary routine of observatory work, observing also the comets of 1836 and 1843, and assisting in the meridional measures which were being taken at that time.

Thomas Henderson, the self-taught astronomer, who occupied successively the positions of director at the Cape Observatory and of Astronomer Royal for Scotland, died prematurely in 1844, and Smyth was appointed to succeed him in the following year, at the observatory on the Calton Hill, Edinburgh. His tenure of this office was one long struggle, continued over forty-three years, to get the Home Office to provide means for a suitable equipment of the Scottish Observatory, which he found in a deplorably dilapitated condition. In spite of the futility of his appeals, he managed to get the observatory into some sort of working order, set up on Calton Hill a time-signalling arrangement by means of a ball which dropped on a staff, and continued to observe the stars and weather.

The enormous increase in the size and power of telescopes had brought out the necessity, foreseen long before by Newton, of choosing for observatories sites which should give advantageous atmospheric conditions. Piazzi Smyth was therefore commissioned by the Government to investigate the atmospheric conditions on the Peak of Teneriffe, and consequently sailed for Teneriffe in 1856. His investigations made it certain that an elevated situation is free from many of the atmospheric disturbances which militate so greatly against star-gazing from low levels. It was not, however, until recent years that his investigations were fully acted upon. The great American observatories have led the way in this respect, and their experience has amply proved the wisdom of care exercised in the choice of sites. For his investigations at Teneriffe, Smyth was in 1857 elected a Fellow of the Royal Society.

Smyth's most important work was done in the department of spectroscopy. He invented the process of examining gaseous spectra by the use of "end-on" vacuum tubes. While at Lisbon in 1877, he drew an elaborate chart of the solar spectrum. He also made a spectroscopic investigation of the zodiacal light, and was the first to discover the harmonies revealed by the lines of the spectrum of carbonic oxide. After his retirement from the position of Astronomer Royal, he improved his chart of the solar spectrum into a larger and more complete form, and at his death left his

property to the Royal Society of Edinburgh for the purpose of publishing all his memoirs on the subject of spectroscopy, and in order to provide means for further researches.

Besides his spectroscopic researches, Piazzi Smyth did much valuable work in collecting records of weather changes. He organised fifty-five stations for meteorological observations throughout Scotland, and published the results which were thus obtained. As a final protest against the indifference of the Home Office, he resigned in 1888, and died on February 21, 1900.

OTTO WILHELM STRUVE

Who Found That Saturn's Rings are Falling In

The famous son of a famous father, Otto Struve was one of the greatest astronomers of the nineteenth century. Born at Dorpat on May 7, 1819, he became his father's assistant at a very early age, and took up enthusiastically the investigation of double stars. His first independent research was on the subject of the movement of the solar system through the celestial spaces. Herschel's determination of the solar apex as situated within the left arm of Hercules had found no support until, in 1839, Argelander carried out much more comprehensive observations for the same purpose, and confirmed Herschel's results by scrupulous examination of the motions of 390 stars. Otto Struve, at the age of twenty-two, determined to test conclusively these results of Argelander's, and in 1841, after a careful study of the motion of 400 stars, he arrived at a determination for the solar apex in close agreement with the conclusions of Herschel and of Argelander.

After satisfying himself with regard to the direction, Struve went on to consider the velocity of the solar motion, but his results in this case are much more speculative, and can hardly be relied upon. He deduced from the average parallax of stars of the first magnitude a velocity of 154 million miles a year; but it is certain that no secure basis for calculation is provided by the average parallax, since only five out of eighteen first-magnitude stars show any measurable parallax.

Baily had published in 1836 his account of the phenomenon known as "Baily's Beads," as observed during the annular eclipse of the sun in 1836, and Struve was among those who were stimulated by this account to run south for the total eclipse of 1842. From Lipetzk he had a magnificent view of the corona, which on this occasion, according to Struve's estimate, extended over a period of twenty-five minutes, the great plumes spreading their radiance to a distance of three or four degrees from the moon's edge.

Otto Struve then followed his father in the investigations of double stars and in the search for stellar parallex. He discovered 500 double stars, the most interesting among them being Delta Equulei. This pair revolves in less than eleven years, a period shorter than that of Jupiter around the sun, and very much shorter than the period of any other known pair. Otto Struve, with the fifteen-inch Pulkowa refractor, had better success than his father in the search for stellar parallax. He detected a parallax of half a second for Aldebaran, and independently confirmed the distance of 61 Cygni, estimated by Bessel at about forty billions of miles.

Besides his researches on double stars, Otto Struve is famous for his theory of Saturn's rings and for his observations on nebulæ, especially on the Great Nebula in Orion. He discovered the strange fact that while the outer edge of Saturn's rings remains always at the same distance from the body of the planet, the inner diameter is gradually decreasing—that is, the ring system is being drawn gradually towards the surface of the planet, and will presumably eventually be precipitated on to it. Struve at first estimated that this would take place in the course of three centuries, but later observations have shown the inward movement to be much slower than he had supposed.

The Orion Nebula came under Struve's observation for many years. He discovered the variability of some of the stars of the trapezium, and made some remarkable observations on the variations in brilliance of the nebula itself. With regard to this latter phenomenon he wrote in 1862: "The observations as to the distribution and brightness of the nebulous matter do not imply any change of form, but many fluctuations in the brightness of the different parts. The general impression I have received from these observations is that the central part of the nebula is found in a state of continual agitation, like the surface of the sea."

Otto Struve became director of the Pulkowa Observatory in 1861, on the retirement of his father; in 1864 he retired from the position for a time on account of severe illness, but was fortunately able to resume it before very long. In 1878, since Pulkowa no longer held the first place among observatories for instrumental per-

tection, he persuaded the Russian Government to build a new giant refractor which should excel all others in existence. Struve himself was appointed to superintend the execution of the work, and went to America to secure the services of the Clarks in the construction of the object-glass. The huge instrument was set up in 1884; and it surpassed every other telescope in power and clearness until the building of the Lick telescope at Mount Hamilton, California.

Struve retired from the observatory in 1893, and was succeeded as director by the late Professor Bredechin, famous for his researches into the theory of comets' tails. Speaking of the work of Otto Struve at Pulkowa, a fellow-scientist wrote, at the time of his death: "In meridian places of stars, in cometary observations, in geodesy, in spectroscopy, the activity and efficiency of the institution have been everywhere acknowledged. Under his care, splendid laboratories have arisen devoted to spectroscopic inquiries; and it is not too much to say that his direction of a world-famous observatory has been of a most enlightened and beneficent character."

Otto Struve was the recipient of many honours, and lived to see his son, Professor Hermann Struve, also receive the gold medal of the Royal Astronomical Society, of which society he was himself elected an associate in 1848, and was awarded the gold medal in 1850. He died at the beginning of May, 1905. "It would be difficult," says his biographer, "to over-estimate the services of Otto Struve to astronomy. Besides his work on Saturn's rings, on nebulæ, and on the solar motion, he is one of the five greatest double-star observers who have ever lived. His reputation is an enduring one, and his name may well be placed among the greatest astronomers of the nineteenth century."

WILHELM STRUVE

A Monumental Cataloguer of Double Stars

Friedrich Georg Wilhelm Struve, generally called the "elder Struve," was the first of a family of brilliant astronomers. His son, Otto Struve, is noticed above; his grandson, Hermann Struve, is one of the notable astronomers of today.

Wilhelm Struve was born at Altona on April 15, 1793, the son of a well-to-do yeoman. He studied at the University of Dorpat, where he graduated in philology at the age of eighteen. But his attention soon centred in science, and with such successful results that in 1813, at the age of twenty, he was appointed director of the new observatory at Dorpat. At the same time he was made professor of mathematics and astronomy in the Dorpat University.

As early as 1819 he succeeded in obtaining a powerful five-foot refractor, and immediately entered upon the studies of double stars which have made his name famous. His energy and enthusiasm in surveying the heavens, and in making his investigations of double stars as complete and comprehensive as possible, were worthy of a follower of Herschel. The results were published in 1837, at St. Petersburg, in a monograph entitled "Mensuræ Micrometricæ." "This monumental work," says the historian of astronomy, "gives the places, positions, distance, colours, and relative brightness of 3112 double and multiple stars, all determined with the utmost skill and care. The record is one which gains in value with the process of time, and will for ages serve as a standard of reference by which to detect change or confirm discovery." Some very interesting generalisations with regard to double stars emerged from this survey. Struve omitted from his classification all apparent doubles of which the components were separated by a distance of more than 32″, since in the case of wider doubles there is an appreciable chance of their juxtaposition being optical and not real. Struve found, from his survey, that at least one in forty of all stars above the ninth magnitude is double or multiple, the proportion being more than doubled in the case of the brighter stars only. Following Bessel's suggestion, Struve took the existence of common proper motion as an infallible test of the reality of systematic relation between stars. Proceeding on these lines, he was led to the conclusion that single stars are certainly not more than twice or three times as numerous as double or multiple systems.

From 1818 to 1821 Wilhelm Struve was occupied in the search for stellar parallax, his main achievement being to prove that the quantities were too small to be measured by any instrument then in use. The Emperor Nicholas of Russia having determined, in 1835, to erect a new observatory near St. Petersburg, appointed Struve to direct the building and equipment. Pulkowa was chosen as the site, and funds were supplied without stint. The observatory was for a long time the finest and the best equipped in the world, so that Pulkowa became known as the "astronomical capital of the world" Wilhelm Struve was appointed director of

the observatory, and this position he retained until 1861, when failing health led him to resign in favour of his son Otto. Wilhelm Struve died on November 23, 1864.

As a student of sidereal astronomy, the elder Struve has hardly been equalled. Both in the investigation of double stars and in the study of stellar distribution he worthily carried forward the labours of Sir William Herschel. His ideas as to the constructions of the heavens were somewhat similar to those held by Herschel. He regarded the Milky Way as produced by a collection of irregularly condensed star-clusters, supposing that the stars composing it lie upon a bent plane, or upon two planes which intersect at a point very near to that at which the solar system is placed. Struve believed that light becomes gradually extinguished in its passage through space, and that consequently the limits of the universe are for ever unfathomable. In this opinion he is opposed by many of the leading astronomers of today, who do not admit the theory of light-extinction, but there remains much to be said in support of Struve's theory.

HERBERT HALL TURNER

A Mapper-Out of the Heavens

Professor H. H. Turner, Director of the Radcliffe Observatory and Savilian Professor of Astronomy in the University of Oxford, was born in 1861. He was educated at Leeds Modern School and at Clifton College, and graduated at Trinity College, Cambridge, of which college he was afterwards elected a Fellow. After several years as chief assistant at the Royal Observatory, Greenwich, he was appointed in 1893 to his present position of Savilian Professor at Oxford and to the charge of the University Observatory, being at the same time elected a Fellow of New College, Oxford.

For many years past the work of the Oxford Observatory staff has been very largely taken up with its part in the construction of the astrographical chart, or the complete photographic survey of the heavens by international co-operation, which was determined on, at the instigation of Dr. Gill and others, at a conference brought together for the purpose in 1885. This small observatory, with limited staff and limited means, has yet, under the splendid organisation of Professor Turner, shown itself capable of competing with the resources of the great national observatories, and has produced results which are second to none. The first of the projected eight volumes of the results was published in 1906, under the editorship of Professor Turner. It includes 65,750 star positions, all within the narrow zone, two degrees in width, which comprises the field of labour of the Radcliffe Observatory. Reviewing the work, a scientific authority has remarked that :

" Professor Turner has exhibited qualities of administration of the highest order. He has instilled his own enthusiasm into his staff of workers, and has secured the uniformity of excellence and rigorous accuracy which are essential for the maintenance of the international repute of the work." Professor Turner's policy has been to set a limit of accuracy in the star measurements which was practically possible to the staff and the time at his disposal, and to adhere rigorously and uniformly to this limit, rather than to attempt a still more absolute accuracy at the risk of introducing new difficulties and complications into the work. " Professor Turner is no doubt warranted," says the authority quoted above, " in asserting that a just relation has been maintained between the labour expended and the accuracy obtained."

In 1912 Professor Turner published a popular account of the design for a complete photographic survey of the heavens, giving the history of the development of the plan, and a sketch of the lines on which it is being carried out. The book is called " The Great Star-Map, being a Brief General Account of the International Project Known as the Astrographic Chart."

Professor Turner is the author of several interesting books on astronomy and its history, including " Modern Astronomy " and " Astronomical Discovery."

Professor Turner discovered in 1903 a " new star " in Gemini, and gave an exposition of his theory of new stars. He regards the dark patches on the celestial sphere, such as the Coal-sack, as not being actually voids in the stellar universe, but as being dark nebulæ which hide the light from the stars beyond. When a star comes into collision with any such mass of dark matter, its temperature is enormously raised by the consequent friction within a day or two, just as a meteor, when entering our tenuous upper atmosphere, is set ablaze.

Professor Turner has invented ingenious devices for the photography of stars, and has made other improvements in astronomical apparatus. He is a correspondent of the Institute of France, and has been President of the Royal Astronomical Society.

BIOLOGISTS

SIR EDWIN RAY LANKESTER

A Famous Darwinian

SIR EDWIN RAY LANKESTER was born in London on May 15, 1847, the eldest son of Dr. Edwin Lankester, who was a well-known writer on scientific subjects. He was educated at St. Paul's School, at Cambridge, and at Oxford, and as early as 1871 made an interesting discovery of the first parasite ever found in the red blood cells of a vertebrate. The most important of such parasites now known is, of course, the organism that causes malaria. Since that date Sir Edwin Ray Lankester has been the occupant of various academic Chairs, in London, Edinburgh, and Oxford. Ever since 1869 he has edited the Quarterly Journal of Microscopical Science. He was Director of the Natural History Museum at South Kensington from 1898 to 1907, and did much to continue the work of Sir William Flower, so that the Museum is now one of the glories of science in this country. In 1906 he was President of the British Association, and he received the K.C.B. next year.

Sir Edwin Ray Lankester has always been a voluminous writer, and he is also a clear and effective lecturer, as was shown in his Christmas lectures to children at the Royal Institution a few years ago, when he dealt with "Extinct Animals." During the last few years he has contributed a weekly article entitled "Science from an Easy-Chair" to the "Daily Telegraph," and he has always been a conspicuous champion of the value of science in national life.

He believes and teaches that science matters for a nation as a whole, and for the right conduct of political and personal affairs; and much is due to him for the advance, in the popular estimate, of science in recent years. He edited the scientific memoirs of Huxley, and more recently has done very much to acquaint the scientific world and the public in this country with the work of Professor Metchnikoff, his friend of many years' standing, whose valuable lecture on the "Warfare against Tubercle," delivered in London late in 1912, we owe to Professor Lankester.

The most weighty and generally significant part of this author's work is to be found in his volume "The Kingdom of Man," published in 1907. Here are to be found the author's Romanes Lecture of 1905, entitled "Nature's Insurgent Son," the object of which, in the lecturer's own words, is "to exhibit in brief the 'Kingdom of Man,' to show that there is undue neglect in the taking over of that possession by mankind, and to urge upon our universities the duty of acting the leading part in removing that neglect." The second part of the volume is the author's presidential address to the British Association, reviewing "the progress made in the last quarter of a century towards the assumption of his kingship by slowly moving Man."

The first paragraph of the Romanes Lecture must be quoted, as giving the chief practical belief of Sir Ray Lankester, in the most cogent possible form.

"It has become more and more a matter of conviction to me—and I believe that I share that conviction with a large body of fellow-students both in this country and other civilised States—that the time has arrived when the true relation of Nature to Man has been so clearly ascertained that it should be more generally known than is at

present the case, and that this knowledge should form far more largely than it does at this moment the object of human activity and endeavour—that it should be, in fact, the guide of State government, the trusted basis of development of human communities. That it is not so already, that men should still allow their energies to run in other directions, appears to some of us a thing so monstrous, so injurious to the prosperity of our fellow-men, that we must do what lies in our power to draw attention to the conditions and circumstances which attend this neglect, the evils arising from it, and the benefits which must follow from its abatement."

SIR EDWIN RAY LANKESTER
From the painting by the Hon. J. Collier

In biological theory Sir Edwin Ray Lankester is a very positive Darwinian. He is consistently and ardently opposed to vitalism in all its forms, and is perhaps the most conspicuous representative surviving of the thoroughgoing so-called "Darwinian" and mechanical theory of life and evolution. He has frequently been in controversy with the representatives of "psychical research" and vitalists of any school. Like his friend Metchnikoff, he attributes a very large part of the death-rate to the consumption of alcohol, and he would suppress the manufacture of spirits.

ANTON VAN LEEUWENHOEK
The Man who First Saw Bacteria

Anton van Leeuwenhoek was born at Delft, in Holland, in 1632. He was apprenticed to the trade of a lens-maker, and soon became known for the very fine quality of the lenses he supplied to those who were then engaged in the new art of microscopy, But in the course of testing the lenses he made he soon became the most expert of their users, and began to make new observations. He used only what we now call a "simple microscope," that is to say, a single lens, but the quality of his lenses was superfine, and the strongest of them are said to have magnified 160 diameters. We are accustomed nowadays to magnifications of 2000 diameters, and as much as 10,000 is attainable, but the possibilities laid before Leeuwenhoek in his day were unprecedented, and, though he had had no scientific training, he made good use of them.

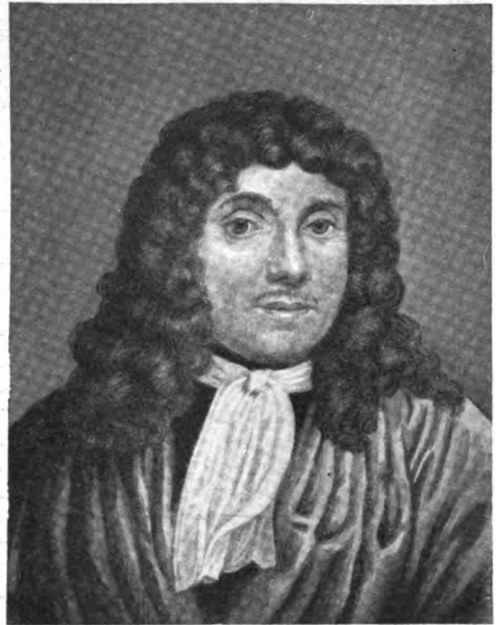
Leeuwenhoek spent the whole of his long life in his native place, but his fame spread, thanks to one of his Dutch contemporaries, and most of his discoveries were published by our Royal Society, while many more were communicated to the Paris Academy of Sciences. Very great incredulity was aroused at first, to say nothing of charges of profanity and gross impropriety in thus peering into "Nature's arcana," to quote his own phrase. There is, indeed, some resemblance between the history of Leeuwenhoek, with his microscope, and that of "the starry Galileo," with his telescope. Each of these patient and honest observers was endowed with a new and supersensible "eye" for the minute and the remote respectively; and each had to meet the objections of those who had not looked, and those who thought such looking sacrilegious. Leeuwenhoek, however, was safe in Holland, the home of liberty, and there he lived in peace. He was elected a Fellow of our Royal Society in 1680.

Armed with his microscope, Leeuwenhoek could see and demonstrate what was even hidden from Harvey—the actual passage of the blood-cells through the capillaries from the arteries to the veins. He took the opportunity to compare the shapes and numbers of the red blood cells in many animals, beginning with the tadpole, in which he, for the first time, could follow the entire circulation of the blood, from the heart outwards, and back again. He also discovered the spermatozoa, or male germ-cells, of animals. These are very much smaller than the ova, or female germ-cells, and

their discovery was of immense importance for biological theory. These observations alone would entitle Leeuwenhoek to be called "the father of scientific microscopy."

This Dutch student also takes a high place in the long controversy regarding what is called "spontaneous generation." In Shakespeare we find the accepted view that "your serpent of Egypt is bred now of your mud by the operation of your sun; so is your crocodile." Leeuwenhoek, with his microscope, set to work to show that, in every case, ova can be found, which are produced by a maternal parent and from which the young are bred, and not from "your mud," or from any decaying matter which may seem to be their immediate source. Thanks to his lenses, he was also able to show how very complicated is the structure of the creatures, simple to the naked eye, which were supposed to be "bred from corruption" by the process of spontaneous generation.

Aristotle believed in spontaneous generation, and thus anyone who attacked it had to reckon with the Church, which, by this time, thanks, above all, to Thomas Aquinas, had accepted Aristotle. Thus, Leeuwenhoek came into controversy with an Italian Jesuit, who declared that shellfish in general are certainly bred by spontaneous generation from mud or sand. Leeuwenhoek showed that this was not so, and added, "For my part, I hold it equally impossible for a small shellfish to be produced without generation as for a whale to have its origin in the mud." Here we see the greatness of this man's thinking, as well as the accuracy of his observation. He was not to be deceived by size. Everyone was content to believe in the origin of large animals from other such animals alone, but it needed a true thinker to see, and a true observer to prove, that what applied to large animals applied no less to small ones—which he proved to be just as complicated in their way. Yet in those days it was the accepted opinion, even among students, that eels were generated from dew; and it needed a Leeuwenhoek, after long research, to discover the tiny young eels lying within their mother's body. Today we marvel that any rational person could have supposed eels to be made from dew, but this is because we are too little aware of our personal indebtedness to the past, and our dependence upon what it has bequeathed to us, thanks to such men as Leeuwenhoek. "Surely no one will be so absurd," he said, "as to retain the notion that any animal, however contemptible in our eyes, can be produced spontaneously or bred from corruption?" And again, "It is my fixed and settled opinion that no leaf, no tree, no root, ever did or ever can produce or breed any animal endowed with life or motion." Today we are all agreed; and everywhere we employ the methods recommended by Leeuwenhoek when he, having found that weevils are not formed from wheat, but in it, recommended fumigation by sulphur in order to destroy them. This seems to be the nearest that the father of scientific microscopy got to the modern "germ-theory" of disease.

Leeuwenhoek made many more discoveries, as regards the structure of the

ANTON VAN LEEUWENHOEK

skin, the hair, the eyes of insects, the fibres of muscles, and the tissues of plants. He lived to gain very great fame, and died, in 1723, at Delft, where he had spent all his life.

CARL LINNÆUS

The Man who Indexed the Book of Nature

Carl Linnæus is the Latinised form of the name of Carl Linné, the great Swedish naturalist, who was born at Rashult, in the Swedish province of Smaland, on May 23, 1707. His mission in life was practically to index the Book of Nature. The start could scarcely have been more unpromising. His father was a poor clergyman, with no thought but that his son should follow in his steps. Linné the elder was an

enthusiastic Nature student, whose little garden contained varieties of plants such as no other local collection showed ; and it was to the Book of Nature rather than to the Book of Theology that the boy was drawn. The indignant and despairing father thought the only alternative to the Church for such a boy was the last of the cobbler, and was about to apprentice him to that humble calling when the schoolmaster, who had detected genius in the lad, intervened in his favour, lent him some books on botany, and got him sent first to the school at Wexiö, and then to the Universities of Lund and Upsala.

The boy's full allowance was £8 per year, and he was so hard pressed that he had to sole his shoes with bark stripped with his own hands from trees. Nothing dimmed his passion for Nature-observing, however; and a worthy professor of divinity, one Celsius, was so attracted by his zeal and originality that he gave him board and lodging free of cost. While he was working away at the functions of stamens and pistils and the meaning of the sexes of plants, Linnæus, who had no idea at this time of the value of his own work, applied for the post of gardener at the University of Upsala, but instead was appointed assistant-lecturer in botany, and given the entire direction of the garden.

For his university he conducted a tour of exploration throughout Lapland, and his bill for the journey of over 4500 miles is said to have been, in our money, £25. He brought back a mass of information on the natural history and ethnology of Lapland, and his success led to his making a similar journey through Dalecarlia (now Kopparberg), at the invitation and cost of the governor of that ancient Swedish province. Linné was enabled to take his degree as M.D., and through the friendly offices of Boerhaave was appointed to the charge of the fine garden and collection of a wealthy Haarlem banker, named Cliffort.

Here he began his series of volumes which laid the foundation of modern botany and the entire classification of plant and animal life. Afterwards he travelled in Holland, France, and England, lecturing, arranging botanical collections, practising as a doctor, and teaching medicine, and, afterwards, botany at Upsala. His fame spread far and near. Travellers from distant lands kept him supplied with an incessant flow of new species of plants and animal life ; students flocked from all parts of Europe to hear his lectures at Upsala. He worked untiringly, classifying, naming, writing, publishing. Seldom has a man achieved so much in so short a time. He first devised his artificial system for the classification of plants, based on a single character—the sexuality of plants. He urged the desirability of a natural system based, not upon a single character, but upon the aggregate of real affinities. When a new species was presented to him he gave it a provisional name until its true affinities should be discovered, applying a second or trivial name, in addition to the generic title, by which to identify the plant. His system has been of great value to botanists.

With regard to animals, he grouped them into species, and the species into genera, the genera into orders, and the orders into sub-kingdoms. He distinguished six sub-kingdoms. We have sixteen or more, with infinite division into sub-classes, with a host of forms of life unknown to Linné's day. He made mistakes, mistakes which seem incredible to-day, such as the grouping of sloths with walruses, but later naturalists with greater knowledge have made blunders just as ludicrous. Considering the limited data at his command, the work of Linnæus was prodigious, and his methods, not in all their details, but generally, stand for all time.

Various minds from the time of Aristotle onwards had dimly groped towards a logical method of classification of plants and animals, but all had failed. Linnæus, working from the slenderest data, had to invent, to create, and found a science ; and science has ever since built upon his foundations. Ray, whose speculations preceded the work of Linnæus, guessed that the world might hold fewer than 4000 species, plus some 20,000 species of insects. Not many forms of life, he said, " of any considerable bigness, in the known portions of the world, have escaped the cognisance of the curious." Linnæus in his " Systema Naturæ," published in 1758, described and named some four thousand species, and expressed the belief that his pages probably did not include half of the species actually existing. Half ! Today we know and have the description of hundreds of thousands of species. Of insects alone 250,000 species have been described, and that number is believed to be but a tenth of the total existing.

So far as the " vegetable race " has been classed, we owe the work to Linnæus, whose labours inspired all that followed after, but we have fewer by half plants than

animals described and named. Still the task swings along with an army of workers behind it. Yet not the half of available knowledge has yet been gained. As with plants, so with animal life. For the last half-century some 12,000 new species have, on the average, been added yearly to the "Zoological Record." And the average is rising. Still inspired by the example and directed by the method of Linnæus, we search the depths of the sea, the jungles of the tropics, the crevices of the coral reefs, the tundras of the North, the limbs of trees, the hair of mammals, the feathers of birds, the body-tissues of mosquitoes—wherever animal life is found. Had we not had the Linnæan system, Sir Ronald Ross could never have identified the mosquito which carries the malarial parasite.

From the teachings of Linnæus in botany equally great results have been won. The seed he scattered has fructified in a thousand minds, so that, for example, from a simple lesson we arrive at the poetry of dynamics in the law that "the whole mass of the earth, from Pole to Pole, and from circumference to centre, is employed in keeping a snowdrop in the position most suited to the promotion of its vegetable health." Linnæus was ennobled in 1761, the first man of science to be so honoured in Sweden. He bought a modest estate, made a famous collection, and maintained his health and mental vigour until a year before his death, which occurred at Upsala on January 10, 1778.

The collection of Linnæus was offered, at his decease, to Sir Joseph Banks. He was unwilling to buy, but mentioned the matter to Sir John E. Smith, then a medical student, who was later to give the world an English translation of one of the dead man's works. Smith borrowed a thousand pounds of his father and acquired the entire collection, herbarium, books, MSS. The King of Sweden was absent from Court when the deal was effected, and, hearing of it upon his return, sent a ship to intercept the vessel which was carrying the treasure away, but was too late. Smith retained the collection throughout his life, after which it passed by purchase into the keeping of the Linnæan Society, which was instituted ten years after the death of the man whose name it perpetuates.

LINNÆUS IN A STATE OF EXHAUSTION ON RETURNING FROM A BOTANICAL RAMBLE

LORD LISTER

The Saviour of Millions of Lives

Joseph Lister was born on April 5, 1827, at Upton, Essex, the home of his father, Joseph Jackson Lister, a man of Yorkshire stock, and distinguished for the great improvement he made in the structure of the

compound microscope, and for his discoveries made therewith. The father was a member of the Society of Friends, or "Quakers," and was connected with brewing, but he sent his son to study arts and medicine, in which he took degrees in the University of London. Soon the young surgeon, who had shown great promise, obtained an appointment at the Edinburgh Royal Infirmary, and thence he went to Glasgow, where he became Professor of Surgery in 1860, and began those particular researches which made him famous. Then he was recalled to Edinburgh, where he became Professor of Clinical Surgery in 1869, and continued his researches, establishing his principles upon a sure basis. Lastly, in 1877, he passed on to London, in order to demonstrate and teach his principles in that recalcitrant metropolis; and he was Professor of Clinical Surgery at King's College from 1887 until his retirement, in 1893.

His scientific achievements gained him innumerable honours at home and abroad. He was created a baronet in 1883, and a baron in 1897, being the first medical man ever raised to the Peerage. He was President of the British Association in 1892, and President of the Royal Society from 1895 to 1900. He was one of the original members of the Order of Merit.

The scientific revolution which clinical surgery owes to Lord Lister need not blind us to the remarkable personal qualities of the man. He was a devoted lover of mankind, like so many members of the religious body from which he sprang. He was thus a beloved doctor, and was immensely successful, not merely because of his skill, but because of his personal force, and the love and confidence which he bred in his patients. No biographical account of Lister can be complete which omits this side of his personality; and it is a circumstance remarkable and fortunate for posterity that, while Lister was a surgeon in Edinburgh, there came under his care a patient who was capable of expressing the qualities of his surgeon in no ordinary way. This was the well-known poet and essayist William Ernest Henley, who was under Lister's care in Edinburgh Royal Infirmary from 1873 to 1875, and there wrote the collection of poems called "In Hospital," one of which, entitled "The Chief," is a sonnet, describing the greatest surgeon of all time.

His brow spreads large and placid, and his eye
Is deep and bright, with steady looks that still.
Soft lines of tranquil thought his face fulfil—
His face at once benign and proud and shy.
If envy scout, if ignorance deny,
His faultless patience, his unyielding will,
Beautiful gentleness and splendid skill,
Innumerable gratitudes reply.
His wise, rare smile is sweet with certainties,
And seems in all his patients to compel
Such love and faith as failure cannot quell.
We hold him for another Herakles,
Battling with custom, prejudice, disease,
As once the son of Zeus with Death and Hell.

Such was Lord Lister to all his patients, from the mere occupant of hospital beds to King Edward VII., when, just before the Coronation, he summoned Lord Lister from his retirement to consult about the need for an urgent operation. In his public lectures and addresses, Lister showed the same great qualities, discussing not himself but the facts and laws of his subject; and he never betrayed or felt any jealousy towards those of his juniors who advanced upon the methods which he had himself introduced. His courtesy was unfailing.

Lister wrote but little outside his strictly scientific contributions. These were collected and reprinted a few years ago, in honour of the jubilee of their author's entrance into the medical profession, and they made two splendid but unfortunately expensive volumes. It is to be hoped that the official Life of Lord Lister, now in course of preparation, will sooner or later be accessible at a moderate sum, like the cheaper editions of the Life of Pasteur.

It was upon the great French chemist that Lister built. In 1874 he wrote to Pasteur as follows: "Allow me to take this opportunity to tender to you my most cordial thanks for having, by your brilliant researches, demonstrated to me the truth of the germ theory of putrefaction, and thus furnished me with the principles upon which alone the antiseptic system can be carried out." When Lister came upon the scene, all was ready for the next step, but he alone took it. Pasteur had done his essential work, but no one saw its significance. Puerperal fever slew thousands; in the Munich hospital "80 per cent. of wounds became affected with gangrene, and filled the surgical wards with horror." In 1868, which we may recognise as the year which saw Lister's introduction of carbolic acid, the death-rate after amputations in hospital stood at 60 per cent. "A pin-prick is a door for death," said a French surgeon, who had perhaps read his "Richard II." and

Shakespeare's account of death, which

Comes at the last, and with a little pin
Bores through his castle wall, and—farewell, king!

Lister was the man who, realising what the pin carries upon its point, introduced the remedy. He had already made several original contributions to science, especially as regards the inflammation and coagulation of the blood, a subject closely allied to some celebrated studies made by his father. Then, in 1867, came his epoch-making papers to the "Lancet," "On a new method of treating compound fracture, abscess, etc., with observations on the conditions of suppuration." The success of this method was indisputable. The death-rate following amputations was at once reduced to one-third; and his wards were the healthiest in the world, while others, separated from his "only by a passage a few feet broad, where former modes of treatment were continued, retained their former insalubrity."

Listerism was adopted at Munich, with its 80 per cent. of hospital gangrene, and "from that day hospital gangrene ceased." The bitter enemies who ridiculed it were soon silenced by the results of its employment, and those results improved year by year as the methods were perfected. Lister's figure of 15 per cent. mortality after amputation, in the first three years of antiseptic treatment, was unprecedented and sensational. Today would it be a scandalous reflection upon the surgeon and the hospital which could report nothing better. And Lister lived to see his methods improve, to direct their improvement himself, until the death-rate due to microbes after operations, where the microbes had not already done their work, has disappeared altogether. The aseptic method of today is the perfection of Listerism; and it is wholly untrue to suggest that it in any way involves an abandonment of the cruder initial methods.

Lord Lister was a man of great muscular strength, who had been a strong swimmer in his youth. During the last year or two of his life he was confined to his bed, and was unable to do anything that made life worth living, but his heart and lungs would not stop working. He died peacefully at length on February 10, 1912, and was buried in Westminster Abbey.

An international memorial to this illustrious benefactor of mankind will take the form of a symbolic monument, like that of Pasteur in Paris, and a fund for the advancement of surgery.

JACQUES LOEB

Student of the Chemistry of Life

Jacques Loeb was born in Germany on April 7, 1859, and was educated in Berlin and Munich, and took his doctorate in medicine at Strasburg in 1884. After some years of research and teaching in Germany and at the famous zoological station at Naples, Dr. Loeb went to the United States in 1891, and has remained there. For some years he was professor of physiology in the University of Chicago; then, from 1903 to 1910, he filled the same post in the University of California, where the greater part of his best-known work was done. In 1910 he left California, and became a member of the Rockefeller Institute for Medical Research, in New York, where he now works.

This record of Dr. Loeb's academic career is very significant, and has several recent parallels. We see a distinguished young European student tempted to the United States by the superior opportunities for research which are there offered in such numbers; and then we find him, at last, liberated from the routine teaching by which most original students in Europe have to earn their bread, and given a post where he can devote the whole of his time and powers to original work. Of course, this does not mean that the researcher ceases to be a teacher, but he no longer needs to teach the rudiments of his science to callow students. He teaches by means of books and papers embodying his own original researches and conclusions. Dr. Loeb is thus a conspicuous illustration of the recent assertion that the scientific centre of gravity of the earth is being rapidly shifted to the United States of America.

Dr. Loeb now writes in English. The first of his important books, published in 1900, was called "Comparative Physiology of the Brain and Comparative Psychology." There followed his "General Physiology," 1905; "Dynamics of Living Matter," 1906; "Artificial Parthenogenesis," 1906; and his latest volume, "The Mechanistic Conception of Life," published in 1912.

The most remarkable of Dr. Loeb's researches are concerned with the development of the eggs of certain animals, especially sea-urchins, without fertilisation. This development of the ovum, without conjunction with a spermatozoon, is technically called parthenogenesis. Dr. Loeb has shown that parthenogenesis can be induced in many species, and that "chemical fertilisation,"

as he calls it, is possible. In other words, by modification of the physical and chemical condition of the fluid in which the ova are kept, it is possible to induce them to develop into perfect embryos, up to certain stages, without fertilisation by the male germ-cells. This has been incorrectly and absurdly described as the creation of life by some writers, but it is obviously nothing of the sort. Parthenogenesis normally occurs in many species, and Dr. Loeb has shown how it may be caused to occur, by modification of conditions, in many more.

It was in 1900 that Dr. Loeb announced his discovery that the parthenogenetic development of the eggs of the sea-urchin, up to the mature stages of growth, could be effected by treatment with chloride of magnesium, and since that date he has been the acknowledged master of experimental embryology. He has directed attention to the importance of the physical process called osmosis, in vital phenomena. The addition of salts to sea-water, for instance, alters its osmotic properties, in virtue of which it, or certain of its constituents, can pass through organic membranes; and hence many of the results which follow such modifications. We now believe that numberless facts of the bodily functions depend essentially upon the laws of osmosis. Dr. Loeb has also adduced reasons for supposing that one of the great functions of the nucleus of a living cell is as a centre and regulator of the oxidation upon which so much depends.

Dr. Loeb has not, however, confined himself to the statement of conclusions dependent upon the researches which have made him so famous. He has written largely upon what are called tropisms—the fashion in which living creatures respond in definite ways to, for instance, light—some being "positively heliotropic," like the moth; others "negatively heliotropic," like the creatures we disturb when we move a big stone from its place in the soil. Thence Dr. Loeb has passed to psychology, and has argued that all the actions of living creatures, all the behaviour and conduct not merely of plants and insects, but of mice and men, are nothing more or less than mechanical tropisms.

In his latest book Dr. Loeb gives us a detailed and comprehensive statement of the theory, held by him today as by so many biologists in the nineteenth century, that biology is simply a branch of applied physics and chemistry, and that life, including all the phenomena of so-called mind, is merely a special case of the working of mechanical laws. Dr. Loeb is thus a foremost figure among materialists.

It has repeatedly been proved that eminence in physical and chemical experiments, such as Dr. Loeb's have really been, does not necessarily qualify a man for discussing the ultimate problems of life and mind. The psychological and philosophical writings of Dr. Loeb have done nothing to advance his reputation, and have been very severely handled by the students of those subjects. Further researches along the lines of those made by Dr. Loeb have also been carried out by Professor Driesch and others, with the result that a wholly mechanistic interpretation is found to be impossible. But Dr. Loeb's work has been invaluable in helping us to elucidate the manner in which living organisms employ the laws especially of what is now called "physical chemistry," and much more of value is to be expected from him, in the realm rather of research than of interpretation.

FRANÇOIS MAGENDIE

An Experimental Student of Living Things

François Magendie was an entire sceptic. As a physician he practised medicine—because he did not believe in it. Born at Bordeaux on October 6, 1783, he won a medical studentship at Paris by a competitive examination in the eleventh year of the French Republic, and took his doctor's degree in 1808. The spirit of the Revolution inspired him, and he set out to overthrow the traditions of medicine with the same ardour as that with which the political revolutionaries had overthrown the traditions of the monarchy.

He began by attacking the work of Bichat, the greatest anatomist of the day. Gathering impetus as he went on, he included all doctors in his fierce, scornful, adverse criticism—except, of course, that very scientific physician of the Hôtel Dieu, François Magendie. Naturally, the young sceptic was vehemently abused by the members of his profession, but he was a first-rate fighting-man. He always hit back harder than he was struck. Gradually a band of disciples gathered round him, and he became the leader of an important new school of experimental medicine.

Whilst working in his own hospital he came to the conclusion that the drugs then lavishly used in the treatment of disease were unavailing. Henceforward, he would allow no drugs to be given to his patients.

Quinine and seidlitz powders were only employed—with a little morphine at times to still excessive pain. Diet and clear water were his medicines, and warm beds and mustard poultices his stand-bys. Practically everything else in the medical art of his time he regarded as part of the armoury of charlatanism, by which his fellow-practitioners tricked the people.

Stern and cold in manner, even to his poor hospital patients, he was yet at bottom touched with an almost despairing pity for the sufferings of humanity. He knew he could do very little to cure them, and it made him bitter and scornful to see other doctors selling vain hopes and vain drugs to stricken sufferers. There were many persons in Europe who regarded Magendie as a monster—the Robespierre of the medical world—for he had a passion for vivisection. He cut up living animals continually and in large numbers. A great deal of his time was given to this kind of experiment in the study of the functions of life.

He was the first to prove that the veins are organs of absorption; and he pointed out that animals cannot live on one kind of food. His researches on the circulation were also remarkable, but it was in the study of the nervous system that he won his highest title to fame. Following up the work of Sir Charles Bell, he clearly demonstrated that the anterior roots of the spinal nerves govern movement, and the posterior roots preside over the function of feeling.

He was made a member of the Academy of Sciences in 1821, and nine years afterwards he was appointed to the Chair of medicine at the College of France. He came to England to study cholera in 1831, and served on the committee of public health. Towards the end of his career he gave himself up entirely to the study of the physiology of plants on his estate at Sannois, near Paris, where he died, on October 8, 1855.

Magendie had all the faults and virtues of an extremist. He went too far in his passion for vivisection; and his Journal of Experimental Physiology, in which his experiments on living animals are recorded, is painful reading. In his utter scepticism in regard to the remedial action of drugs, he also went too far. But the general effect of his extreme views was good. They were needed to balance the defects of men of the opposite school. Magendie was one of those men who resolutely put everything to the test. His keenly critically attitude was in the long run creative, and not destructive, for though he threw away some valuable things, these were afterwards recovered, but much of the rubbish of tradition was gone, and a clear path for the future scientific development of medicines was made by him. When we consider that practically nothing was known in his time of the origin of most diseases, and especially the part played by harmful microbes, his attitude of scepticism seems to have been wise. He was a brave, honest doubter, and by discrediting false ideas he greatly helped to promote the discovery of the real facts.

SIR PATRICK MANSON

A Pioneer Fighter of Tropical Diseases

Sir Patrick Manson, the modern leader in the study of tropical diseases, is the son of John Manson, of Fingask, Aberdeen, and was born on October 3, 1844. After studying as a doctor he went to the island of Formosa, and in mingling with the people he acquired a deep interest in tropical diseases. One curious malady—elephantiasis—had a special fascination for him. He puzzled over the problem of its origin, but was unable to find a satisfactory solution. He went on to Amoy, a large coast-town of China, and there he saw many more cases and many more forms of the strange malady. But he still failed to find an explanation. In 1874 he came to London, and heard

SIR PATRICK MANSON
Photograph by Lafayette

for the first time that Timothy Lewis, one of the pioneers in the study of tropical diseases, had discovered an organism in the blood of certain natives of India. This organism he called "filaria sanguinis hominis" It is a minute thing, shaped like an eel, and enclosed in a loose sheath, within which it wriggles in a very active manner in the blood of persons afflicted with elephantiasis.

Sir Patrick Manson returned to China in 1876, and began to search for these parasites. He found that in some districts 50 out of every 100 Chinamen had the organism in their blood. In other places no human beings were found with it. Pursuing his researches, he ascertained that the filaria was only a very young animal, and he traced the parent in another part of the body, where it sometimes grew to four inches in length. But between the mature animal and its tiny, wriggling progeny no intermediate form could be discovered. So Sir Patrick Manson arrived at the grand problem in many tropical diseases—how does the parasite contrive to pass from one human being to another? He came to the conclusion that mosquitoes were the agents in transmitting the malady.

He placed a Chinaman suffering from the disease under a mosquito-net with some hungry mosquitos. The insects attacked the patient, and Manson then attacked them with his dissecting instruments. Placing the contents of the stomach of the first mosquito under the microscope, he saw that instead of the digestive juices of the insect killing the filaria, they only stimulated the mischievous little animal to fresh activity. Continuing his experiments, he allowed some mosquitoes to live after they had fed on the patient, and then dissected them.

He then found out that the parasite had during its stay in the mosquito grown from the size of one-hundredth of an inch to that of one-sixteenth of an inch. It was just visible to the naked eye, it had developed a mouth, and it was ready to enter and feed on the blood of the first human being the mosquito bit. It wandered into the proboscis of the insect, and waited for an opportunity to escape. As in the case of the malarial parasite, both man and the mosquito are necessary for the complete development of the agent of disease. Therefore, if the mosquito is destroyed, the parasite cannot live, and the disease ceases.

Sir Patrick Manson's work had the magnificent result of opening up a new system of preventive medicine in all diseases in which insects act as carriers of maladies. In particular, it was the first large step for checking the dreadful diseases of the tropics that make those regions the grave of white men, and spread suffering and death among millions of the natives. The discovery is indeed likely to change the future course of development of a large part of mankind, and to change it for the better. Appointed Medical Adviser to the Colonial Office, Sir Patrick Manson succeeded in establishing Schools of Tropical Medicine in London and Liverpool. He himself became director of the London school. A brilliant son, who bravely submitted to be bitten by a mosquito and infected with malaria in order to prove conclusively Sir Patrick's theory, perished a few years ago by accident while on an expedition. Sir Patrick was knighted in 1903.

GREGOR JOHANN MENDEL

The Monk who Changed the World's Thought

Gregor Johann Mendel was born on July 22, 1822, at Heinzendorf, in Austrian Silesia. His father was a small peasant proprietor, and it is probable he was not of Jewish origin, though his name suggests that he was. Mendel's father was interested in fruit culture, and early taught him the methods of grafting; and a maternal uncle started private classes to teach the children of the village, where there was no school.

Mendel was a promising boy, and received a good education, involving a very heavy tax upon the family purse. One of his teachers was an Augustinian, and Mendel was admitted to the monastery of that Order in Brünn, being ordained a priest in 1847. Johann was his baptismal name, and he assumed that of Gregor "in religion." The monks sent the brilliant novice to the University of Vienna, where he studied the physical sciences, and then came back to Brünn, and taught science in the school there. He was a very successful teacher, and continued this work, throughout the period which made his present fame, until he was elected abbot of the monastery in 1868.

There was a large garden in the cloister, and there the young student, whose father had shown him some of the wonders of experimental botany, began many observations on the behaviour of various plants which he had introduced into the garden for the purpose. Somewhere about 1857 he started his special experiments on the breeding of peas, and these he continued for eight years, reading his paper to the Philosophical Society of Brünn in 1865. It was

published in 1866, and the issue of the transactions containing it was sent to various scientific societies throughout the world, including the Royal Society and the Linnæan Society of London. But no one noticed it, nor the paper on the plant hieracium, which was read in 1869 and published in 1870.

Mendel must have been a very hard worker. He was teaching all this time, not perfunctorily, but *con amore*, as we know. He was conducting his immensely laborious observations on the pea, but he had many other irons in the fire. He was especially interested in the heredity of bees, and had fifty hives under observation. He collected queen-bees from various continents, and studied the results of their matings. In 1905 Dr. Bateson, to whom the scientific world is indebted for the collection of the biographical data here used, paid a visit to Brünn, but could find no trace of Mendel's work on bees beyond the hives which he had used. Mendel is known to have made many notes on his experiments, but it seems likely that he destroyed them during the period of depression from which he suffered before his death. " A rich harvest of discovery," says Dr. Bateson, " awaits those who may successfully repeat the work ; " and in the last year or so some of that harvest has been reaped by observers who have gone to work on Mendelian lines.

No more scientific work came from Mendel after his appointment as abbot. He himself had hoped otherwise, and expected that, after a time, he might find better opportunities for research than ever. But the very qualities and dogged determination which had served him so well in his wearisome researches of eight years upon one species showed themselves now in a disastrous form. Here is Dr. Bateson's account of what was, in effect, a catastrophe that delayed the advance of biology for a generation : " In 1872 the Government passed a law imposing special taxes on the property of religious houses. This enactment Mendel conceived to be unjust, and he decided to resist, claiming that all citizens should be equal in law, and that if these taxes were imposed on one class of institution they should be imposed on all. He thus took up a position which in England we should call that of a 'Passive Resister.' At first several monasteries stood out with the Königskloster, but gradually they conformed, Mendel alone remaining firm. The quarrel involved him in protracted trouble and litigation. High emissaries are said to have visited him, proposing a compromise, and even offering honours in case of submission. Old friends and acquaintances tried to influence him, but it was all in vain. He attended neither to cajolement nor menace. The property of the house was eventually distrained upon, but he did not give in. He became also involved in the racial controversies which are often rife in this part of Austria, and it is only too certain that the last ten years of his life were passed in disappointment and bitterness. From being a cheerful, friendly man he became suspicious and misanthropic."

It is a deplorable story, on our account as well as Mendel's. Dr. Bateson notes, as a piece of history, that, a few years after Mendel's death, the tax against which he had fought " was removed without debate or dispute." We must deeply regret the loss of the work in genetics which Mendel would have done had not this accident happened, but we could have done without that if only the abbot had retained interest enough in his past work to direct the attention of the scientific world to it. Other workers, all over the world, would then have verified his results and gone forward. A single copy of his paper, " with the writer's compliments," addressed to Darwin at Down would have changed the scientific history of the nineteenth century.

Mendel was a born observer, and even the counting of scores of thousands of peas did not exhaust his aptitude for arduous hobbies. He made and published regular meteorological records, observed, drew, and recorded sunspots, and made notes upon their supposed connection with terrestrial weather. He was a good business man, and was chairman of a bank in Brünn. He was also a brilliant chess-player, and composed many problems. We may add that he also solved the problem of the " knight's move " form of inheritance, where a characteristic appears in uncle or aunt, and nephew or niece. In Heinzendorf, his birthplace, he also organised a fire brigade.

We can well believe that this clear-headed, practical, determined man was seriously disappointed at the neglect of his work by his contemporaries. He tried to interest the great Naegeli, who did not respond, and apparently he never tried again, while the copies of his paper which were sent to the great capitals remained unopened, we must presume.

Here it is only necessary to say that, by mating peas which were contrasted in

certain characters, and observing the characters and numbers of the offspring, thereafter *mating them among themselves*, and observing the characters and numbers of their offspring, Mendel was able to frame a statement of inheritance which is now known as Mendel's law, and to frame a theory of what he called "segregation," which asserts that, when individuals bearing opposite characters are mated, producing a "hybrid," the "factors" for those characters do not *both* go into its germ-cells, but segregate, so that any given germ-cell either contains the factor for the one character only or for its opposite only. This law of segregation was shown by Mendel to apply to various characters in the pea and in hieracium, but we do not know whether he discovered it to apply to any characters in the only animal form he observed, which was the hive-bee.

It need hardly be said that a host of observers, before Mendel, had mated individuals, animal and vegetable, who bore opposite characters, and had noted the results. None of them had found anything definite, constant, or significant; and we now know that success was only to be attained by an observer who should use the laborious method of Mendel—studying one pair of characters at a time, observing three generations always, never mating different generations, and counting the numbers of each kind of individual produced in each generation. Little can be done on these lines with one's feet on the mantelpiece.

The last decade of Mendel's life was sad and unproductive, as we have seen; indeed, it may have involved destruction of much that earlier years had produced. In 1882 Darwin died, having never heard the name of Mendel. There is nothing like this case in the history of science, and we can scarcely believe that its like can ever happen again. It must remain deplorable and unique to the end of time. Two years later, after a long period of physical ill health, as well as mental depression, Mendel died at Brünn, on January 6, 1884.

In 1900 his paper was discovered, his results verified, and a new chapter in the history of biology opened.

ELIAS METCHNIKOFF

And the Possibility of Prolonging Life

Elias Metchnikoff, whose first name is often given as Elie in a French version, was born of Jewish parents at Kharkoff, in Russia, on May 3, 1845. Elias is the modern Jewish form of Elijah; and those who have seen and heard Professor Metchnikoff may feel that the prophetic name is not ill applied. The young student was educated at the Gymnasium and University of Kharkoff, passing through the Faculty of Science, and then, after some researches in zoology, he was appointed professor of that subject at Odessa. He made various zoological expeditions—to Madeira, Teneriffe, and the Kalmuck Steppes—at this time. In 1882 he devoted himself specially to bacteriology, and in 1888 he went to the Pasteur Institute in Paris, where he has worked ever since, and of which he is now the sub-director.

From Dr. Chalmers Mitchell's introduction to the English translation of the "Nature of Man," published here in 1903, much else may also be learnt about its renowned author. The young Metchnikoff, as a zoologist, spent many years in studying the development of insects, worms, jellyfish, sea-urchins,and other lowly invertebrate animals. Not even he could then have guessed that "from these remote, inhuman interests" he was soon to pass "without intellectual transition to results affecting vitally the human race." But it was so. As Dr. Mitchell reminds us, "From observations made originally on water-fleas, he was led to discover the functions of the white corpuscles of the human blood. He showed by what mechanism these made perpetual war against the intruding microbes of disease, and he laid the foundations of our knowledge as to the agencies that weaken or that strengthen these guardians of our health. In a series of investigations into the phenomena of inflammation in men and lower animals, he carried his observations into new fields, and explained the relations of the white corpuscles to the juices that attract and repel them."

Professor Metchnikoff's book on "Immunity in Infective Diseases" has been translated into English, and is a classic upon the subject. His initial discovery of the function of the white cells of the blood, which he taught us to call the "phagocytes" or eating-cells, opened the way to further great advances, which have notably been taken by Ehrlich in Germany. For some time Ehrlich's view came to be generally entertained—that the white cells do not do the essential work of protection, but that they devour invading parasites after the task has been made easy through the poisoning of the parasites by substances which have first come into action. But Metchnikoff argues that, in point of fact,

the substances which act upon the parasites, so that the phagocytes can digest them, are first produced by the phagocytes; all the honour rests with them.

At the present time the study of immunity centres round this problem, and on the whole it is fair to say that the most recent evidence has tended to restore our estimate of the phagocytes to the level set by Metchnikoff a quarter of a century ago. They do produce powerful ferments, the most important of which is trypsin, and by this means they do wonders for the protection of the body. Hence the latest method of treating tuberculosis, and helping the phagocytes to kill the microbes, is by the injection of trypsin into the affected part.

A few years ago Professor Metchnikoff gave an important series of lectures in London, under the auspices of the Royal Institute of Public Health. He then referred especially to his own work, and notably to his later researches on the ways in which the phagocytes may be helped or hindered in their work. He mentioned specially his detailed studies of alcohol, which he has proved intoxicates the white cells, and therefore must be entirely banished from medical practice in all diseases due to microbes. As the most authoritative opinion in the world, based upon exact and confirmed evidence, this has had a great effect upon medical methods during the last half-dozen years.

A few years after this visit to London Professor Metchnikoff was awarded the Nobel Prize in medicine, this being in the year 1908. It had been well earned, above all for the fundamental discovery upon which modern theories of immunity and susceptibility must depend, and afterwards for the long researches by which Professor Metchnikoff has been able to direct the practice of hygiene in so many respects. Late in 1912 Professor Metchnikoff visited London again, and gave a lecture at the Royal Society of Medicine on "The Warfare against Tubercle." Little public notice was taken of this lecture, and the attendance at it was little creditable to English medicine. But it was a most important pronouncement, the central part of which consisted in arguments to show that recovery from certain types of infection by tuberculosis confers an immunity against subsequent attacks. Professor Metchnikoff believes that this natural vaccination, so to call it, against tuberculosis largely occurs in cities today, and that it, above all, accounts for the great fall in the tuberculous death-rate which has occurred in most parts of the civilised world during the last half-century.

It is astonishing that so little notice has been taken of the expression of this startling yet entirely reasonable theory by the greatest of living authorities. The immediate duty of science is now to discover whether the theory is true. Professor Metchnikoff is engaged upon that work; and he hopes that it may be possible to find and cultivate mild strains of the tubercle bacillus which can be used for purposes of protection by acquired immunity, on exactly the same principle as the use of vaccinia, which is modified smallpox, for protection against that disease. Meanwhile, the new view is extremely disconcerting to those who have supposed that the presence of tubercle bacilli in milk is an unmixed evil.

Two books have been written by Professor Metchnikoff for the educated public. The later and less important is called "The Prolongation of Human Life," and deals mainly with the theory that man's life is unnaturally shortened by the poisonous products which are formed in his alimentary canal by certain microbes. Hence Mechnikoff introduced lactic acid as an ingredient of diet, since the dangerous microbes can only live in an alkaline medium, and lactic acid will destroy them. Evidence in favour of this theory was found by Metchnikoff in the great longevity of the Bulgarians, who live largely upon sour milk. Metchnikoff has taken such milk himself for many years, and his example has been widely followed, the hope being that the microbes which produce the milk-acid will live in the bowel, and control those which produce the alkaline poisons. Time is still required before we can decide upon the value of this method, but it is certain that Metchnikoff's theory is sound; and the only question seems to be whether lactic acid, taken by the mouth, can ever reach, without first being neutralised, the remote coils of the bowel where its action is required.

More important is the notable book on the "Nature of Man," published in this country by Mr. Heinemann in 1903. In these "Studies in Optimistic Philosophy," to quote their sub-title, Professor Metchnikoff argues that man, descended from animal ancestors, still has within him a number of "disharmonies," of structure and foundation, which gravely hamper and endanger him in the new and higher life

which he now leads. These disharmonies must be studied and understood, in the light they throw upon the nature of man, and then we must do what we can to remove or control them. Such views are now established and appreciated by all reasonable men, and they look largely to science as the instrument by which the part of man's nature called the intellect may more than compensate for the many disharmonies of his constitution. In the great warfare with disease the name of Elias Metchnikoff will be that of a leader and a prophet.

PETER CHALMERS MITCHELL
A Practical and Reforming Zoologist

Peter Chalmers Mitchell was born in Dunfermline on November 23, 1864, his father being a minister. He studied at Aberdeen, Oxford, and upon the Continent, inclining first to literature and later to science. For some years he taught biology at Oxford, and to medical students at various London hospitals; and in 1903 he was appointed Secretary to the Zoological Society of London. He has since gained various honours, including the Fellowship of the Royal Society.

Dr. Chalmers Mitchell's contributions to science may be discussed under two heads—of literature and of practice in Regent's Park. He is a lucid, scholarly, and distinguished writer, and has been most industrious with his pen. In 1900 appeared his book on Huxley. In 1903 he translated and edited Metchnikoff's "Nature of Man," to which he wrote an introduction of rare and memorable quality, upon the functions of science in the coming world, and the high dignity of those who devote their lives to the service of knowledge. "In every country," he concluded, "the new Order of priests of science, in the vigils of the laboratory, is working for the future of humanity." Students in this country owe much to Dr. Mitchell for his work in bringing to their notice this and other important foreign publications. Zoologists are indebted to him for many technical articles in scientific journals, and he has also served the public in general by the numerous valuable articles which he has contributed to the most recent editions of the "Encyclopædia Britannica."

But during the last decade Dr. Chalmers Mitchell has been concerned above all with the study and the actual care of living animals. His secretaryship has marked a new epoch in the history of the famous Gardens in Regent's Park, and great success has followed his work, both as regards our knowledge of animals and in respect of the public interest in and appreciation of the Gardens. The death-rate among the animals has been greatly reduced. The daring policy has been followed of exposing numerous tropical animals, large and small, to the open air of London, including its fogs, instead of keeping them in artificially warmed houses. In some cases the fogs have killed animals, and always will, but they have not been the tropical animals. A young walrus, on the contrary, was a notable recent victim. But the monkeys and many other tropical creatures have thrived as never before under the new conditions, and the prevalence of tuberculosis in the Gardens has greatly diminished.

Under the wise and skilful policy of Dr. Mitchell, the Gardens are now in a state of unexampled interest and variety. Visitors and students are provided with trustworthy modern accounts of the various animals. Thanks to a generous benefactor, the work begun by Dr. Mitchell is now being greatly extended, and in a short time many animals will be kept and exhibited under almost natural conditions, as in Mr. Carl Hagenbeck's wonderful park at Hamburg. A splendid hospital has also been provided in the last year or two, and nervous or ailing patients are at once removed from the boredom and exhaustion which even human beings may suffer from uninvited guests.

Dr. Mitchell is very fond of animals, and has made interesting studies of such creatures as a young caracal which he kept in his house as a domestic pet. He showed this young animal, and many others, at his Christmas lectures at the Royal Institution recently, and since then he has published a book embodying the substance of those lectures, and called "The Childhood of Animals." This entirely delightful book has earned great success, and should be read by every student. At the Dundee meeting of the British Association in 1912, Dr. Chalmers Mitchell used his opportunity as president of the section of Zoology to plead for what he called "Nature reserves," where the natural fauna of all civilised countries may survive, free from the murderous attentions of "sportsmen," so that future generations may profit by their use and beauty.

ST. GEORGE MIVART
Evolution Under Divine Guidance

Many of the new ideas of the part played by life itself in the evolution of species are old ideas. Long before Bergson and

Hans Driesch set out to oppose Darwin's theory of natural selection, St. George Mivart began the attack from a similar point of view. The great English anatomist's ideas were partly based on those of Aristotle, and partly worked out by original researches into the structure of the higher animals. In immediate results his views were a failure. By means of them he attempted to reconcile modern evolutionary science with the most dogmatic form of Christianity, Roman Catholicism, but he incurrred the condemnation of both Professor Huxley and Cardinal Vaughan.

St. George Jackson Mivart was the son of a hotel proprietor, of Brook Street, Grosvenor Square, London, the father being sufficiently wealthy to enable the son to devote himself entirely to the pursuit of knowledge. Born on November 30, 1827, Mivart was educated at Harrow and King's College, and it was intended he should go up to Oxford. But at seventeen he joined the Roman Catholic Church; and as Oxford was then closed to him, he completed his education at St. Mary's, Oscott. In 1844 he entered Lincoln's Inn, and studied for the Bar. At the end of five years he was made a barrister, but in the meantime his tastes had changed. The law had no attraction for him; he took up medicine, and became interested in anatomy.

Then from the study of the human frame he worked to that of the apes and the great flesh-eating animals. For many years he laboured at his own cost; and it was only gradually seen that a great master of the structures of life had arisen in our country, among the same class of men of wealth and leisure as that to which Darwin and Galton belonged. An appointment as lecturer at St. Mary's Hospital, Paddington, in 1862, was the first recognition of Mivart's genius; and soon afterwards he was generally admitted to be the first authority on the bodily relationships of man and the higher apes. The lower animals with a backbone were also his special study.

On his own ground he spoke with more authority than either Darwin or Huxley, the connection between men and monkeys being particularly his province. He did not speak until Darwin published his "Descent of Man," but then he came forth as an opponent of the theory of natural selection. He did not attack the idea of the evolution of life—he was himself an evolutionist—but he denied that evolution had been brought about in the manner advocated by Darwin and Wallace. He held that the survival of the fittest in the struggle for existence was not the factor of supreme importance. In his view this struggle was a matter of comparatively small moment. It did not explain the grand difficulties of the evolution of life. There were jumps from one species to another; and no theory of the slow accumulation of small variations could explain the breaks, for in many cases the change of form had to be sudden and fairly complete to be of use to the organism.

He conceived that there is a unifying power in living creatures that organises their varied activities, and shapes them into new forms in response to the stimulus of the material circumstances of their existence. In the old theory of "vitalism," this unifying power was regarded as a kind of separate soul inhabiting the body, and distinct from it. But in Mivart's "neo-vitalism" the creative organising force is regarded as part of the visible body, so that it and the body are one thing, as an impression on stamped wax and the wax itself are one thing. In modern phrase, he believed that there is a life-force in every plant and animal, unifying its activities and directing its orderly development when circumstances are favourable. This, in his view, is the main creative power in evolution, while the process of natural selection merely checks in some cases this creative force.

Of course, this theory of neo-vitalism removed the problem of the real origin of species from the province of scientific analysis. It left the mystery of life in mystery, for it was impossible to verify by the senses the existence of the principle of life. But Mivart pointed out that as an intellectual conception his theory of neo-vitalism could be accepted as a rational explanation of the facts. He asked Christian theologians to allow that God had breathed into matter the life-forces, with all their marvellous latent powers of development. Then, he considered, the facts of natural history could be studied scientifically in themselves, and man could trace the way in which the structure of his body developed, by a natural Divine law, into the temple of an immortal spirit. Excommunicated in January, 1900, Mivart died on the first of April of that year.

JOHANNES MÜLLER

A Great Physiological Thinker

Johannes Müller was born at Coblenz on July 14, 1801, and from 1824 to 1833 studied and taught physiology in the University of Bonn. There his work gained him such distinction that in the latter year

he was appointed professor of anatomy and physiology in the University of Berlin, and there he remained for the rest of his life.

Like other physiologists, Müller made many researches into the details of his science, and his work extended also to comparative anatomy, where he studied the lancelet, the fishes, and sea-urchins in especial. His physiological observations dealt with the blood and with the mechanism of speech, among many other subjects. But his name will always be remembered as that of a great physiological thinker—the numbers of whom in all time are scant indeed, though capable physiologists are always plentiful. Müller has indeed been often ranked as the founder of modern physiology; and his great work, the "Handbook ot Human Physiology," which was published during the 'thirties of the nineteenth century, made an epoch, thanks to the profound intellectual powers of its author.

Physiology needed a thinker. Facts had been collected, with great speed and of great consequence, in the generation before Müller's time; but a multitude of facts is not a science, any more than a heap of stones is a cathedral. Müller resolved the chaos of data into a cosmos. He thus became the greatest teacher of physiology that this science has ever known. The masters who have since flourished in Germany, from the illustrious Helmholtz downwards, were nearly all pupils of Müller, and ungrudgingly acknowledged their debt to him.

His most important and profoundest contribution to his science was the generalisation which is now known as Müller's law. It is sometimes also called the "law of specific nervous energy." It states the remarkable truth, discovered by Müller, that the sensations we experience depend upon the innate powers of the sensory centres concerned; so that if *any* agent excites the centre for vision or the centre for taste, vision and taste are respectively experienced. Not light merely excites vision, but also pressure and electricity. Subtler internal causes may excite vision also, as in dreams; but if the visual centre acts, *vision and nothing else* results. This discovery carries us far into the mysterious depths of physiological psychology Johannes Müller died on April 28, 1858.

ARTHUR NEWSHOLME

An Official Initiator of Health-Schemes

Arthur Newsholme was born on February 3, 1857, and studied medicine at St. Thomas's Hospital, London, taking his doctorate in medicine in the University of London in 1881. He early determined to devote himself to State Medicine, or Public Health, and published his "Elements of Vital Statistics" in 1889, after several years of further study in hospitals and elsewhere. He has edited journals of public health, has lectured before the Royal College of Physicians, and examined on this subject in several universities. He has been President of the Society of Medical Officers of Health, and of the Epidemiological Section of the Royal Society of Medicine, and held a similar position at a recent International Congress in the United States. For many years he was medical officer of health for Brighton, where he initiated many steps in the care and prevention of tuberculosis in especial. In 1908 he was appointed by Mr. John Burns to be Chief Medical Officer to the Local Government Board.

Dr. Newsholme has studied many infectious diseases, and has contributed papers on them to the medical journals, but his chief work has been upon and against tuberculosis. Before the present century began he was advocating the notification of consumption, and in 1908 he published his most important book, "The Prevention of Tuberculosis," in the New Library of Medicine. In that book he argued that consumption might be controlled and ultimately abolished by the adoption of the principles which led to the extermination of leprosy in past ages; and he adduced copious statistical evidence to show that a rapid diminution in the incidence of the disease is associated with the isolation or segregation of advanced and acutely infectious cases in institutions. He regards the great extension of institutional treatment as a leading cause of the great diminution of consumption in this country.

Since the publication of this book, and Dr. Newsholme's appointment to the Local Government Board, notable steps have been taken in the direction of his policy, by means of Orders issued by the Board. First, notification of poor-law cases of consumption was made compulsory. From January 1, 1912, all cases of consumption were made compulsorily notifiable, and since February 1, 1913, all cases of tuberculosis have been compulsorily notifiable. The inauguration of this policy, to be followed by segregation of infectious cases in sanatoria, and by other measures, will doubtless lead to the prevention of tuberculosis, as prophesied by Dr. Newsholme, and greatly furthered along his lines since 1908.

MAX NORDAU

Does Civilisation Lead to Degeneration?

Max Simon Nordau is the name assumed by the brilliant son of a Hungarian Jewish scholar, Gabriel Südfelt. Born in Pest on July 29, 1849, Nordau was educated as a medical man in his native town, but turned to journalism as a means of livelihood, and spent some time in travelling about Europe. For six years he wandered through the centres of modern civilisation. Vienna, Berlin, and Paris were the places at which he stayed longest, but he roamed from Russia to England, and from Scandinavia to Spain and Italy. In 1878 he settled down in Pest, and began to practise as a doctor, but apparently he did not find the medical art as lucrative as journalism, and at the end of two years went to Paris as a special correspondent. And there he has remained.

Nordau began his career as a journalist in 1872, when he went on the staff of the "Pester Lloyd." Later he worked as a writer of serial stories on that journal; and the "Frankfurter Zeitung" and the "Vossische Zeitung" published much of his work. Since 1881 he has been Paris correspondent for the last-named German paper. His career as a journalist and as a writer of feuilletons must be taken into account in discussing his work as a man of science. Nordau has never lost his love of creating a sensation; he has something of a journalist's delight in making a "scoop," and he certainly works out his ideas for all that they are worth.

His early medical studies led him to take an interest in the researches of Lombroso into the signs of nervous and intellectual degeneration. Suddenly it struck him that the evidence which the Italian man of science had collected among the criminal classes of Italy could be applied in diagnosing the poets, painters, and writers of the decadent school in France. It was notorious that some of the French bohemians of the period were leading unhealthy lives. Nordau mixed with them for a while, studying them with the eyes of a journalistic physician with a theory to prove. Naturally, he was able to prove that a poet who habitually took absinthe as a source of inspiration was a degenerate. But he went on to show that, from his point of view, almost every composer, poet, novelist, and painter of genius in modern Europe was an example of "degenerate psychoses of the epileptic group." It seemed as though the genius and the criminal were both madmen, and that the insanity of genius was undermining civilisation. Only in sane philistinism was there any refuge from the asylum.

Nordau's own genius for exaggeration was a marked characteristic of his famous work on "Degeneration." Appearing in 1893, the book made a sensation throughout the civilised world, for there were undoubtedly at that time signs of decadence in literature and art. In our country, men of the stamp of Aubrey Beardsley and Oscar Wilde had introduced something sinister into the intellectual life of the nation. Things were still worse in France, and as bad in Germany and Italy. The weakening of religious faith, the spread of luxurious habits, and the passion for novelty at any cost had led some writers, painters, and musicians into perilous paths, but the entire movement was a shallow and a passing thing. It did not affect the general life of the people, and it soon lost its force.

Nordau took it and himself too seriously. He fastened his label of insanity on everything and everybody he disliked—on Wagner and his music, on Tolstoy and his novels. In his hands "degeneration" became not a theory but a bludgeon, and he tried to strike down every figure of importance in European art and letters, with the exception of a few men who, like Gerhard Hauptmann in his play "The Weavers," used their art to forward the doctrines of Social Democracy. In recent years Max Nordau has been closely associated with the Zionist movement for resettling the Jews in Palestine.

SIR WILLIAM OSLER

A Cosmopolitan from the New World

Sir William Osler, the Regius Professor of Medicine at Oxford, was born at Bond Head, in Canada, on July 12, 1849, the son of a clergyman of the Church of England, of Devonian descent. He is one of four brothers, all of whom have made positions of distinction for themselves, two in the law, the other in finance. Sir William Osler was educated for the medical profession at Toronto, Montreal, London, Berlin, and Vienna. His first academic appointment was to the Chair of Medicine at McGill University, Montreal, in 1874. Ten years later he became Professor of Clinical Medicine in the University of Pennsylvania; and five years later still Professor of the Practice and Principles of Medicine in the Johns Hopkins Medical School in the Maryland University, Baltimore. From this appointment he passed to Oxford in 1905. Sir William has received honorary degrees from many other

universities besides those with which he has been associated as a student or teacher.

Osler's contributions to literature have had a wide range. They include not only "The Principles and Practice of Medicine," which has gone through many editions, and, as editor, "A System of Medicine" in seven volumes, with a number of publications on special studies of obscure forms of disease, but also addresses to students on the human side of their profession—their relation to patients, nurses, and the public. At Harvard he widened the range of his topics by an address on "Science and Immortality," in which he expresses the opinion that in scientific circles faith is no longer diversified by doubt, but doubt is diversified by faith. He, however, would rather, like Cicero, be mistaken with Plato, if it be a mistake, than be right with those who deny the life after death.

Sir William Osler had a great reputation in the American Republic for his power of diagnosis by a kind of instinctive insight—the most physicianly of all qualities—and as a stimulator of the students who came within the range of his personal influence. He made a special point of urging his students to keep abreast not only with medical practice, but with the thought of the times, so as to preserve the mental freshness and breadth of outlook which they, perhaps most of all men, need. His own success is a proof of the fact that the physician's influence is largely a question of masculine sense and personality.

SIR RICHARD OWEN

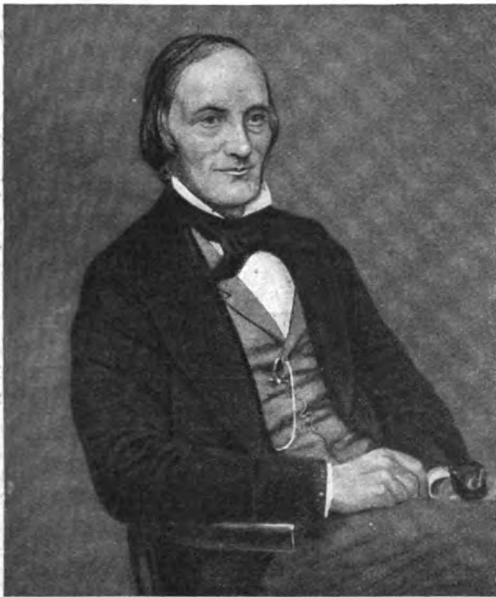
A Reader of History Written in Bone

Sir Richard Owen, one of the most famous of comparative anatomists and palæontologists, was born at Lancaster on July 20, 1804, younger son of a West India merchant. After attending the local grammar school, where he showed no indication of the talent latent in him, he was apprenticed at sixteen to an apothecary and surgeon. With other pupils, he was given access to the county gaol, where they were permitted to conduct post-mortem examinations, and he became greatly interested at once in the study of comparative anatomy.

He passed from Lancaster to Edinburgh University, where he matriculated, and underwent the training proper to the career of a surgeon, but went to London for his diploma, intending all the time to join the Navy as a doctor. At this period his career greatly resembled that of Huxley. He was disappointed of his hopes; so, simply to mark time, and keep body and soul together, he accepted a minor position in the Royal College of Surgeons, as assistant to Clift, John Hunter's most devoted assistant. Owen joined Clift in the HunterianMuseum of the College. Here was the richest collection of anatomical specimens that had ever been got together in the history of the world. The Government had bought them at the death of Hunter, and here they were, after forty years, uncatalogued, useless. It fell to the lot of Owen to catalogue and arrange them, and the result of his labours was an incomparable series of monographs, and, later, a valuable edition of the works of Hunter himself. He interpreted Hunter to the world, and gave to humanity the wonderful story revealed by the magnificent collection got together by that prodigy of zeal and wisdom. In course of time, Owen married the daughter of Clift, and succeeded her father as curator.

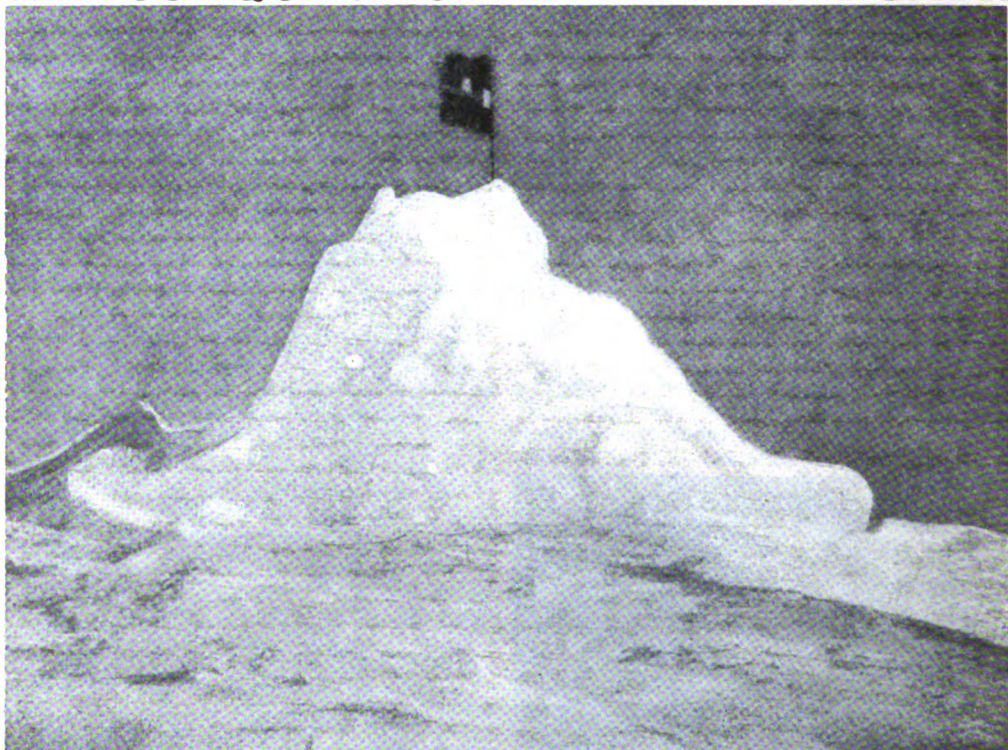
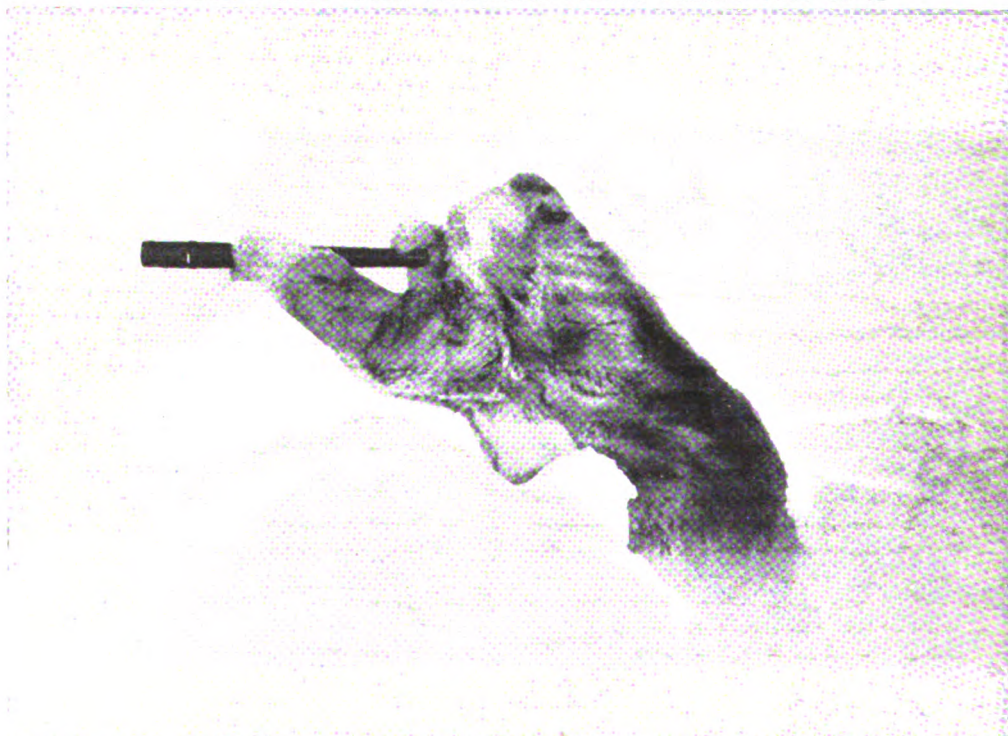
The young couple had rooms at the College of Surgeons, and their home developed into the strangest museum in the world. Owen undertook the dissection of all the animals that died at the Zoological Gardens. Many of them were taken to his rooms; and the dinner of the young people would be interrupted by the arrival of a dead lion or kangaroo, a bear or a baboon, a crocodile or a pelican. He lectured and wrote upon physiology, upon palæontology, upon morphology. His investigations covered the whole range of animate creation, from sponges to man. His influence upon the learning of his age was unbounded. Although he was opposed to the Darwinian theory, his very researches helped enormously to prove the conclusions he assailed. Lecturer, writer, demonstrator, called to adjudicate at exhibitions, and to sit upon important Commissions, he grew in power and repute with all but the people who should have assisted him. He might call at Buckingham Palace and Windsor Castle, and lecture to the Royal children, but official England was as hopelessly uninterested in science as it was when Melbourne insulted Faraday. Consequently, Owen, whose reputation was now practically world-wide, remained poor.

We find Macaulay, friend to learning, very anxious about the affairs of Owen in 1856. He is writing to the Lord Lansdowne of the period, urgently suggesting the reform of the British Museum, and the installing of Owen in charge of the department devoted to geology, zoology, botany, and mineralogy. "I cannot but think," he wrote, "that this arrangement would be beneficial

in the highest degree to the Museum. I am sure that it would be popular. I must add that I am extremely desirous that something should be done for Owen. I hardly know him to speak to. His pursuits are not mine. But his fame is spread over Europe. He is an honour to our country, and it is painful to me to think that a man of his merit should be appproaching old age amidst anxieties and distresses. He told me that eight hundred a year, without a house in the Museum, would be opulence to him. He did not, he said, even wish for more. His seems to me to be a case for public patronage. Such patronage is not needed by eminent literary men or artists. A poet, a novelist, an historian, a painter, a sculptor,

SIR RICHARD OWEN

who stood in his own line as high as Owen stands among men of science, could never be in want except by his own fault. But the greatest natural philosopher may starve while his countrymen are boasting of his discoveries, and while foreign Academies are begging for the honour of being allowed to add his name to their list." Owen was appointed to the position suggested—it was created for him—and we get our superb Natural History Museum in its present form as the result of that appointment.

From this time forth Owen threw himself with still greater ardour into the work of his life. He had all the riches of the Museum to work upon, with teeming treasure sent to him from all lands for inspection, classification, and description. He first taught naturalists to distinguish between analogy and homology. He first brought the torch of learning to bear upon the mysteries of parthenogenesis—that is, the reproduction of their kind by female types of life deriving their fertility from the ova from which they themselves are born. In a thousand directions he enlightened and taught his generation. He achieved many marvels of intelligent anticipation as the outcome of his own system. Perhaps his greatest triumph in this direction was his description of the extinct giant moa from the single leg-bone of the bird which was first sent him. The bone was as huge as that of a giant ox. But he declared it a remnant of a bird, and lived to have before him the entire skeleton of a moa, and to be photographed with it, holding in his hand a fragment of the bone from which he had described it.

Owen was not infallible. He insisted on regarding man as a creature apart from all other creation. He was invincibly opposed to the doctrine of natural selection. There is little doubt that he primed the brilliant but shallow Bishop of Oxford for his onslaught on Darwin at the historic meeting of the British Association. Darwin was perhaps never angry with any but one man—and that one was Owen. But, as against his stubborn indifference to the volume of evidence brought to bear in support of the Darwinian theory, a multitude of magnificent achievements by Owen have to be placed in the opposite side of the scale. Science was advanced a century through his labours in elucidating the mystery of animal life past and present. Practically every learned body in Europe honoured him, and the Queen of England gave him for life the use of the charming Sheen Lodge, in Richmond Park, but Gladstone was taken by surprise when it was suggested that the great scientist should be knighted. Owen was near eighty at the time, and with all his modesty was not unwilling, simply for the sake of science, that the dignity should be his. "The chief satisfaction I should feel," he explained, "by such an instance of recognition would be in regard to the relation of my own to that of other countries in the estimate which has been allotted me." And he follows with a detail of services to the social life of the nation and to science generally which has probably no parallel. Owen died a knight, but he would not have done so had not Playfair loyally pressed his claims. His death occurred at Sheen Lodge on December 18, 1892.

EXPLORERS

FRIDTJOF NANSEN

A Hero of the Great White North

FRIDTJOF NANSEN, the most scientific of Arctic explorers, is the son of a Norwegian lawyer. Born near Christiania on October 10, 1861, he first distinguished himself as a ski-runner. When but four years old he took to ski-ing, and in 1882 he carried off the prize awarded to the best ski-runner round Christiania. His passion for this exciting sport, which the Norwegians learnt from the Lapps, was of supreme importance in his life. It directly led to his work as an Arctic explorer. Moreover, he owed to it that splendid physique that enabled him to bear the rigours of long journeys on foot across icy wastes. Tall, blue-eyed, and trained down to the last ounce, he holds that no form of sport so evenly develops the muscles, makes the body strong and elastic, and teaches dexterity and resource, as ski-ing.

He needed a great deal of open-air exercise in youth and early manhood, for on entering the University of Christiania he specialised in zoology, and spent most of his time in peering through a microscope, examining the structure of the nervous system of all kinds of animals. In 1882 he went on a sealing-ship to the Polar Seas to search for a new species to dissect and examine; and in the same year he was appointed curator of Bergen Museum, winning a gold prize for his study of a certain worm. Characteristically, he took the medal in copper, and applied the value of the gold to the expenses of a journey to the famous Marine Laboratory of Naples.

The tissues of the nervous system looked like becoming his object of study throughout life. But in 1883 the Swedish explorer Nordenskjöld came back from Greenland, after finding that the interior was an endless snowfield. Nansen, the ski-runner, was then inspired with the idea of attempting to cross Greenland, from coast to coast, on skis. He had often travelled seventy miles a day across the snow in this manner, and it seemed to him that a small band of ski-runners would succeed in making the first crossing of that strange, vast land of ice and snow discovered by the ancient Vikings.

It was in 1887 that he published his plan, and appealed to the Norwegians to subscribe the small fund necessary for the work of exploration. There was a storm of opposition; he was denounced as a madman in search of a new form of suicide. He received, however, applications from forty men willing to accompany him, and the financial help that he vainly asked from his countrymen was generously given by a Danish gentleman, who sent £300 to cover the entire cost of the expedition.

With five companions, some River Lapps and some Norwegians, and five sledges, Nansen landed at Anoritaka, in Greenland, on July 17, 1888, after fighting for nearly twelve days in an ice-stream off the coast. The crossing of the great ice plateau was begun at Umivik on August 10. Steep, irregular slopes, soft snow, and dangerous crevasses so impeded the explorers that by August 27 they were only forty miles inland, at a height of 7000 feet. The cold was so intense that even the woollen socks on their feet froze. They were storm-bound for days; their tents were torn by tempests, and their provisions grew at last so scanty that they had to race with death across a tableland of ice 9000 feet high to the west coast of Greenland. Their skis enabled them to sail rapidly over long distances, but near

the coast they again met rough, irregular ice and crevasses that seriously delayed them. On September 29, after a journey of 260 miles, they reached an inlet fifty miles from Godthaab, and, by means of a boat made of canvas, willows, and sledges, assistance was obtained from the little Greenland town. In June, 1889, the party returned to Norway in the best of health, having accomplished the first crossing of Greenland. Nansen's brilliant achievement is remarkable for the boldness of the plan, and for the energy and endurance with which the physical difficulties were overcome.

In 1881 the "Jeannette," commanded by

FRIDTJOF NANSEN

De Long, an American explorer, was crushed and sunk in an ice-pack to the north of Siberia. Three years afterwards some Eskimos on the south-west coast of Greenland picked up a large number of articles belonging to the "Jeannette." This extraordinary event made a deep impression on the mind of Nansen. The idea that he worked out from it was confirmed by the discovery of twelve species of microscopic plants on the east of Greenland which were identical with those found in Behring Strait, Putting these facts together, he concluded that a strong ocean current ran from the east Siberian ice-pack, right across the North Pole, to the coast of Greenland, carrying the ice with it as it flowed.

Acting on this theory, Nansen designed a small, slow ship, with sloping sides that could not be crushed by the ice. By reason of her rounded build, the pressure of the floes could only lift her up, instead of crushing her. Her screw and rudder were made so that they could be raised and protected from the ice in a kind of well. The "Fram," as the ship was called, was too much like a tub in shape to be pretty, and, though small, she cost nearly £10,000 to build. On June 24, 1893, the "Fram" left Norway with a crew of thirteen daring sailors, and pushed along the coast of Asia towards the New Siberian Islands. There Nansen ran her into the ice-pack, but for months the "Fram" was carried south-eastward in the wrong direction. Suddenly, the ice movement turned, and the strange, vast march of the pack set towards the Pole. Ridge after ridge of huge ice-blocks were forced up in the winter darkness around the little ship. At times the noise was so terrific that the men in their cabins could hardly hear themselves speak, but the vessel did the work for which she was designed, and remained unhurt.

Early in 1895 the "Fram" was carried beyond the most northerly point reached by man. But the journey had been very slow, and Nansen resigned the command of the ship to Captain Sverdrup, and, accompanied by Lieutenant Johansen, set out on a sledge expedition towards the Pole. They had three sledges with nine dogs to each, but the ice was very rough, and the sledges were frequently overturned. Seven miles a day was good going. The temperature was often 49 degrees below zero, and Nansen and his companion were often hard put to it to continue their journey.

On April 7, 1895, they reached 86° 14′ North—about 200 miles nearer the Pole than any other explorer had then gone. Scarcity of provisions then compelled them to return, but, instead of trying to regain the "Fram," they struck homeward towards Franz Joseph Land. There they wintered in a hut which they built out of stones and walrus hides. About the middle of June, Nansen was amazed to hear a dog bark. Going towards the sound, he met Mr. Frederick Jackson, of the Jackson-Harmsworth Expedition, and returned to Norway on his yacht. The "Fram" in the meanwhile drifted to 85° 57′ North, the highest latitude ever attained by a ship, and

then fought her way out of the ice, and arrived at Norway a very short time after Nansen and Johansen arrived home.

Amundsen, the first discoverer of the South Pole, is convinced that Nansen is right in his theory of a current running from East Siberia to Greenland, past the North Pole. He intends to provision the "Fram" for six years, and let her drift, if possible, all the way. This will probably be the next piece of Polar exploration of importance.

Of late years politics have occupied a considerable part of Nansen's time. He was one of the leaders in the movement of secession from Sweden, and he has acted as Norwegian Ambassador to Great Britain. But he has continued his scientific work, and he is a high authority on oceanography, that fine modern science of the life and wonders of the deep seas to which he has contributed much valuable matter in connection with the study of the Polar waters.

NILS ADOLF ERIC NORDENSKJÖLD

Discoverer of the Polar Way to China

Just three and a quarter centuries after Sir Hugh Willoughby set out from London on a voyage round Siberia and began the search of the North-East Passage to China, a Swedish man of science accomplished the task. He was Baron Nils Adolf Eric Nordenskjöld (pronounced "Nordenshield"), and was born at Helsingfors, in Finland, on November 18, 1832. His father was a superintendent of mines; and after accompanying him in 1852 on an exploring expedition to the Ural Mountains, the young Finlander also took up mining, and became at twenty-four a clerk of the mines and a curator at Helsingfors University.

His liberal views in politics, however, brought him twice into conflict with the Russian authorities in Finland, and, loving freedom more than comfort and influence, he left his native town, settled at Stockholm, and took out letters of naturalisation. He was appointed Professor of Mineralogy at Stockholm in 1858, and the following year made an expedition to Spitzbergen to study the geology of that group of Arctic islands. In the course of nine years he made four voyages to Spitzbergen, and carried out important scientific researches there.

In 1870 Dr. Oscar Dickson, a wealthy man of Gothenburg, who had provided the funds for the explorer's last voyage, generously placed another sum of money at Nordenskjöld's disposal. With it the adventurous man of science attacked the western side of Greenland, and succeeded in penetrating farther into the bleak and icy interior than any other man had gone. Again helped by Dickson, the explorer began in 1875 and 1876 to explore the edge of the Polar Sea to the north of Siberia. He was one of the first men to see that the development of steam-power had changed the conditions of the problem of the North-East Passage, and that a good steamer could succeed where all the sailing-ships for more than three hundred years had failed.

The King of Sweden, Dr. Oscar Dickson, and Mr. A. Sibiriakoff equally contributed the necessary funds, and a steamer, the "Vega," was purchased by the Swedish Government for the expedition, and manned by officers and men of the Swedish Navy. A smaller steamer, the "Lena," was built of steel to carry some of the stores and coal, and to go in advance of the "Vega" and examine the state of the ice. On July 21, 1878, the "Vega" left Tromsö, sailed across the Kara Sea, and reached the north point of Asia on August 19. All went according to Nordenskjöld's calculations. In his earlier voyages he had found that the warm water from the great rivers of Siberia kept the ice in late summer from closing in upon the land. This fact inspired him with the idea of attempting a Polar voyage from the Atlantic to the Pacific.

He had, in places, both water and ice to contend against, but they did not stop or hurt his ship. On reaching the delta of the Lena, on August 28, the steel-built tender turned south, and explored the river as far as Yakutsk, while the "Vega" skirted the New Siberia Islands. But Nordenskjöld was at last stopped by ice on September 12, at Irkaipi, the North Cape of Captain Cook, where, under similar conditions, the famous English navigator had been forced to turn back to Behring Strait in 1779.

Working her way southward through the gathering ice, the "Vega" reached Kolyuchin Bay, immediately to the westward of Cape Serdze Kamen, and Nordenskjöld and his crew were cheered by the knowledge that they had only to round this promontory in order to pass safely into the Pacific Ocean. But the ice was closely packed, cold weather at once set in, and, by October 1, the "Vega" was fixed in an ice-sheet strong enough to travel over. Here, only 120 miles from Behring Strait, the explorer and his men had to remain for ten months. The members of the expedition passed the time in making important scientific observations and collections, and entertaining one another The ice broke on July 18, 1879.

Two days later the "Vega" rounded East Cape and completed the North-East Passage. The successful voyage greatly stimulated navigation along the Siberian coast, and opened a new path to the North Pole afterwards taken by Nansen and others.

Returning by the Suez Canal, Nordenskjöld arrived at Stockholm on April 24, 1880, and was made a baron in recognition of the new honour he had won for Scandinavia. In 1883 he returned to Greenland, and, adventuring again into the interior, discovered that a vast, unbroken glacier covered the whole of the country. This discovery inspired Nansen with the daring

MUNGO PARK

idea of crossing Greenland on skis. Nordenskjöld died on August 12, 1901.

MUNGO PARK

The Doctor who Began the Exploration of the Niger

Mungo Park, the heroic pioneer of North African discovery, was born on September 10, 1771, at Foulshiels, near Selkirk. His father was a cottager who raised himself to the position of a small farmer while bringing up a family of thirteen. One of the daughters married a gardener, who, by hard work and study, became a well-known botanist and a man of social position. From him Mungo acquired the love of botany, a general interest in science, and, what was equally important in shaping his career, an introduction to Sir Joseph Banks, one of the managers of the African Association. The object of the Association was a promotion of discovery in Africa. In 1788 they sent out Ledyard, but he died of fever at the beginning of his travels. In 1791 Major Houghton was charged with the exploration of the Niger, but on his way to Timbuctoo he was murdered by the Moors. Thus everything attempted by the Association ended disastrously. This famous scientific body, which afterwards developed into the Royal Geographical Society, was in a very critical state in its history when Mungo Park volunteered to continue the work of African exploration.

He was then a man of twenty-four. He had studied medicine at Edinburgh, and, having no money to set up in practice, had shipped as a surgeon on a voyage to Sumatra in the East India Company's service. He was looking for work when Banks recommended him to the African Association. The services of Park were eagerly accepted, and on May 22, 1795, the young explorer sailed to the River Gambia. He stayed for some months near the coast in order to acquire the native language. Then, on December 2, 1795, he set out for the unknown interior, with a negro servant and a black boy. His baggage consisted of provisions for two days, a sextant, a compass, a thermometer, and a small assortment of beads, amber, and tobacco. Following the road that had led Houghton to his death, and getting among the natives of Senegal, he was robbed of his amber and beads.

About half way to Timbuctoo, Park was arrested by a troop of Arab soldiers, who led him to Benown, the camp of King Ali. The Arabs and Moors at this time possessed all the trade of Northern Africa, and they regarded every attempt at European exploration as an attack upon their trade. They were afraid that where the explorer went the merchants of Europe would follow. That is why they had killed Houghton. To them an explorer was a spy, and, having got Park into their power, they insulted him and ill-treated him, and it was more by luck than by skill that the Scottish doctor escaped with his life.

Happily, he succeeded in making friends with Fatima, the Sultan's favourite, and, fleeing alone, destitute of resources, during a retreat from some invaders, Mungo Park reached the goal of his travels, "the long-sought-for, majestic Niger, glittering in the morning sun, broad as the Thames at

Westminster, and flowing slowly eastward."

He had now arrived at Sego, the capital of Bambara, but the king refused to receive him, and forbade him to remain in his capital. Mungo continued his journey down the banks of the Niger towards Timbuctoo, but he was now so poor that he had to rely upon public charity. Moreover, the rainy season had set in, and it became impossible to travel otherwise than by boat. Having no boat, and no means of getting one, Park had to turn back at the town of Silla, when only twelve days' journey from Timbuctoo.

He obtained food by writing talismans for the ignorant natives, who had never before seen a white man, and regarded him as a person with supernatural powers. So large did the demand become for his written charms that he grew fairly well off. But on crossing a desert he was robbed of his horse and clothes and goods by a band of brigands. Worn out, destitute, and attacked by fever, which for five months kept him prostrate, Mungo Park stayed at Kamalia, where he was taken care of by a negro trader. On April 19, 1797, he was well enough to be able to join a slave caravan bound for the Gambia River, and on June 10 he returned to the factory of Pisania, which had been the starting-point of his journey.

By this time everybody had come to the conclusion that he had met with the fate of Major Houghton. When he returned to England, having made the greatest discovery in the history of African exploration —the Niger—he was received with enthusiasm. Six feet in height, with a handsome, striking face and fine eyes, he was warmly welcomed in London society; but after he had written with much difficulty and modesty the story of his adventures, he returned to Foulshiels and married. The remuneration he received from the African Association, and the profits from his book, placed him for the time in easy circumstances, and there was a chance of a Government post being obtained for him in New South Wales.

But Mungo Park felt the same attraction to the unknown, mysterious city of Timbuctoo as some Arctic explorers feel for the Pole they have vainly tried to reach. He brought a Moor from London to Foulshiels, and learnt Arabic from him, and in 1804 he received a commission from the Colonial Office to resume the exploration of the Niger. He set out from the Gambia River on April 27, 1805, but as soon as he struck into the interior his men began to sicken and die from fever. By July 29, twenty had died or been murdered, and the rest were unfit for work. At the beginning of August, Park was the only European with any strength left. On the 19th of that month, with the helpless, shattered remnant of his caravan, he reached the summit of a hill, and saw again the wide waters of the Niger rolling through the plain. Three-fourths of his soldiers had died on a march through nearly a thousand miles of hostile country, and Park himself was attacked by dysentery. But, taking to a canoe, he sailed down the river towards Timbuctoo.

SIR WILLIAM EDWARD PARRY

The Moors continually gathered on the banks and fired at him, and he passed Timbuctoo with only seven soldiers remaining alive. Farther down the river, a fleet of sixty canoes attacked him. These were beaten off; and after a voyage of over 1000 miles down the Niger the country of the Moors was passed, and the land of the negroes entered. But, in buying provisions from the blacks, Park excited their cupidity by the rich present he made their king. Thinking him wealthier than he was, they attacked him at Busa rapids, and there Park and his little band of followers were massacred as they were struggling through the rocks. This probably occurred in the autumn of 1805.

SIR WILLIAM EDWARD PARRY

The First Sledge Expedition Towards the Pole

Sir William Edward Parry, one of the most remarkable navigators of the old school, was born at Bath on December 19, 1790. The son of a distinguished physician, he entered the Navy in 1803, when Napoleon declared war against our country, and at nineteen was promoted lieutenant, and sent with a frigate to Spitzbergen to protect the British whale-fishery. His work inspired him with that interest in Polar exploration which became the passion of his life. In 1818 he was given the command of a brig, the "Alexander," and was sent with Sir John Ross to discover the North-West Passage. This was the first expedition that followed the track of the great Elizabethan navigator, Baffin. Ross did little more than confirm Baffin's discoveries, and there was a general dissatisfaction over his failure.

A month after his return a new expedition was arranged, and the command of it was given to Parry. With two ships, the "Hecla" and the "Griper," Parry left Yarmouth on May 12, 1819, and, forcing a passage through the ice on Baffin Bay, reached Lancaster Sound on August 1. This was the point at which Ross had turned back, thinking the Sound was only a bay. Finding open water, Parry crowded sail westward, and discovered a magnificent series of unknown waterways. Lancaster Sound gave way to Barrow Strait, which broadened into Melville Sound. As the ships sailed along, the needles of their compasses began to play strange tricks. At one spot a freely suspended compass-needle stood practically upright, while a little before it pointed due south, instead of due north. The fact was that Parry was passing above the North Magnetic Pole.

Stopped at last by heavy ice, the explorer wintered on Melville Island, and, by a land journey, discovered the open sea leading to Behring Strait. It was too far north, however, to make the passage to China, for the channel remained blocked all the year with ice from 40 to 100 feet thick. So Parry was reluctantly compelled to turn back, and, after one of the most remarkable of Arctic voyages, reached England in November, 1820. He had carried the English flag more than half way from Greenland to Behring Strait, passed to the north of the Magnetic Pole and the American continent, and discovered in Lancaster Sound a new whale-fishery that proved of extraordinary value to our country. Only one of his crew died during the voyage of exploration, and his death was not due to any Arctic cause.

Parry received a reward of £5000 offered by Parliament to the man who first passed the half-way spot between Greenland and Asia. Then the Admiralty fitted out another expedition under his direction. He sailed in May, 1821, with the "Fury" and "Hecla," with orders to proceed through Hudson Strait and seek a passage by this route to the Pacific. Parry obeyed orders, and found that the strait led to a land-locked bay. So he turned north, having lost much time, and was compelled by the ice to winter off Melville Peninsula.

From some Eskimos he learnt there was a strait right at the north, and, when the ice broke up in July, 1822, he sailed northward, and discovered the Hecla and Fury Strait. But the ice was still unbroken in the western part of this channel, and Parry had again to winter in the Arctic. The next summer his crew were so enfeebled that he was compelled to return with his two ships to England. A third expedition was fitted out for him in May, 1824, by the Admiralty. But this time the ice in Baffin Bay was very bad, the "Fury" was wrecked, and the men returned to England in October, 1825. This misfortune of Parry was afterwards the salvation of Ross. When on the point of dying from starvation, with all his men, Ross found, and lived on, the stores of the "Fury."

Giving up the search for the North-West Passage, Parry made a gallant attempt to reach the North Pole. He worked out a plan of sailing his ship as far into the ice-pack as possible, and then sledging over the ice. Fixing on Spitzbergen, the scene of his earliest Arctic voyage, as the centre of operations, he reached Trurenberg Bay in the "Hecla" on June 20, 1827, and the next day set out, with twenty-eight men, and two boats fitted with steel-shod runners to serve as sledges. He found the ice-floes small and loose and very rough, and fog and rain added to the difficulties. The party took provisions for seventy-one days, and travelled about 580 miles. This was the distance from the "Hecla" to the North Pole, but Parry only reached 82° 45′ N., which was 172 miles from his ship.

The fact was, the party was travelling on a vast ice-sheet, which was moving south. Sometimes, when they advanced eleven miles in a day, and then lay down to sleep in their sledge-boats, the drifting ice carried them seven miles to the south. It

was on July 20 that Parry discovered this extraordinary event. He saw it was impossible to reach the Pole under the conditions in which he was working, so he returned to England, having achieved merely the farthest north at that time, and for forty-eight years afterwards. He was knighted in 1829 for his discoveries, and promoted rear-admiral in 1852.

For many years he was Hydrographer to the Admiralty, and towards the end of his life Lieutenant-Governor of Greenwich Hospital. He died at Ems on July 8, 1855.

ROBERT EDWIN PEARY
The American who Found the North Pole

Rear-Admiral Robert Edwin Peary was born at Cresson, Pennsylvania, on May 6, 1856. After studying at Bowdoin College, in Maine, he became a civil engineer in the United States Navy in 1881. Three years afterwards he assisted in surveying the course of the inter-oceanic canal which his country at that time thought of constructing through Nicaragua, and in 1887 he was made engineer-in-chief of the Nicaragua canal survey. But he had already begun his attack upon the North Pole by a reconnaissance, in 1886, of the inland ice-cap of Greenland.

All his leisure time for the next five years was devoted to studying the conditions of Arctic exploration, and preparing his plans for his expedition of 1891. He rounded Greenland, breaking one of his legs on the voyage, marched across the northern end of the vast, glacier-covered island, and discovered Independence Bay. In 1893 he spent two more years in the Arctic, working among the Eskimos of Smith's Sound, and, in the course of his wanderings, found huge meteorites near Melville Bay.

In July, 1898, he again set out north, for the purpose of exploring the lands above Greenland, and attempting the North Pole. On this occasion he was away for four years, and he made some remarkable and difficult sledge journeys. In the spring of 1902 he set out over the Arctic Ocean, from the north coast of Grant Land, in another attempt to reach the Pole. But at latitude 84° 17′ N. the route became impassable, and he had to turn back.

In the summer of 1905, however, he was back again amid the ice, and at the end of a year he came nearer to the Pole than any other man had then attained. In all, Rear-Admiral Peary has spent twelve years inside the Arctic circle, and made eight voyages and six attempts to reach the Pole. He has always taken the route through Smith's Sound, partly by reason of the fact that he found there a tribe of splendid Eskimos, who were the most northerly inhabitants of the earth. Much of his time was given to studying them, helping them, and making friends with them, for he foresaw from the first that they would be of the greatest use to him in his exploring work. The society that provided the funds for some of the explorer's expeditions began to despair of hearing that the American flag

PARRY'S EXPEDITION IN SEARCH OF THE NORTH-WEST PASSAGE IN 1819

had been planted at the North Pole, but Peary was still undaunted. His courage and his perseverance increased under difficulties and disappointments until the man became practically a Polar fanatic. Beneath all his fanaticism, however, there were the native shrewdness of his race and an incomparable store of special knowledge of every detail of Arctic exploration.

None of his achievements was a piece of wasted work. From each he learnt something that helped him to his ultimate success. In 1908 a club was formed at New York to subsidise him in his eighth voyage into the Arctic Ocean. By this time Peary had learnt that the North Pole was, like Russia, mainly protected from attack by "General February." So his new expedition set out in large force early in the season, leaving its winter quarters in the middle of February. The party consisted of seven white men, seventeen Eskimos, with nineteen sledges and one hundred and thirty-three dogs. Having so large a staff, Peary was able to send a light advance party to prepare the trail, and then turn back successive divisions at different stages of the journey, leaving the final dash for the Pole to be made by a small number of men, well equipped and comparatively fresh.

So excellently was the famous expedition planned and equipped that, far from suffering any ill effects from hard work and intense cold, the party increased in fitness and training as they advanced towards the Pole. At a camp at 87° 47′ N., Captain Bartlett and the last supporting party returned, leaving Peary and a negro servant and three Eskimos to make the last spurt. Peary took with him five sledges and forty of the best dogs. On April 1, 1909, the American explorer resumed his march northward, hoping to reach the Pole by five marches of twenty-five geographical miles each. At the end of the fifth march a sudden break in the clouds somewhere about noon enabled Peary to determine his position as 89° 57′. After resting for a few hours, he set out with a light sledge, drawn by a double team of dogs, and, carrying only his instruments, went on for another ten miles. Then, as the sky cleared, he took observations, and found that he had gone beyond the Pole.

He returned to camp, and struck eastward for eight miles, and there took more observations, and again found that he had reached and crossed the Pole. Five miles from the strange, empty waste of ice that so many men had vainly given their lives to reach, Peary found a crack in the ice, and, boring a hole there with a pickaxe, he took a sounding of 9000 feet, and found no bottom.

Having planted his flags on the hillock of ice representing the North Pole, Peary returned south by forced marches. The expedition reached Cape Columbia in such fine trim that the men crossed to Cape Hecla, and thence to the ship in two marches of forty-five miles each—a magnificent piece of work after the greatest and most difficult feat of exploration in history. For more than a score of years the North Pole has been the object of Peary's every effort; he has spent nearly twelve years out of twenty-three, between his thirtieth and fifty-third birthdays, in the frozen wilderness. No man has worked so hard at the task, so none so thoroughly deserves the pure and noble fame which Rear-Admiral Peary has won.

WILLIAM MATTHEW FLINDERS PETRIE

Who Went Back Ten Thousand Years

Professor William Matthew Flinders Petrie, the greatest explorer with a spade that ever worked amid the sands of Egypt, is a grandson of Captain Matthew Flinders, who, as a midshipman, first circumnavigated Tasmania, and afterwards explored more than one half of the coast of Australia. Professor Flinders Petrie was born at Charlton on June 3, 1853. At twenty-five he began the work of his life by studying Stonehenge and other prehistoric remains in his native country. He entered on his work of digging up history in 1880, and in 1892 was appointed Professor of Egyptology at University College, London. In the same year he founded the Egyptian Research Account, which has developed into the British School of Archæology in Egypt.

Flinders Petrie is renowned for the important discoveries he has made. He has changed completely our knowledge of the earliest civilisations; he has found the Egyptians of the Stone Age; he has unearthed some of the earliest kings of the Age of Bronze, and has united the story of Egypt with the story of the surrounding empires by discovering the letters that passed between the rulers of these great nations more than 3500 years ago. None of these achievements was due to happy chance. They fell to Flinders Petrie because he was the first man to reduce the search and the excavation of antiquities to a laborious science founded on large

experience and careful and exact methods. When he first came to Egypt another English antiquarian begged him to pack and send him a box of pottery fragments from each great town, on the chance that from the known history of the site some guess could be made as to the age of the objects—so complete was the ignorance of the fundamentals of archæology thirty years ago. Now, thanks largely to Professor Petrie himself, a bit of pottery is the most valuable material an excavator can find in digging in strange places. It provides him with a date.

and by working with his men he learned to tell, often from the look of the ground, if there was anything buried there.

His most surprising discovery was made at the burial-place of the Egyptian kings of the First Dynasty. For four years a French exploration party, under the direction of Amelineau, had been digging away at the spot, and had opened all the tombs but one. The French excavator was so certain that he had exhausted the site that, though there was another year of his concession to run, he would not trouble to work any more at the place.

ROBERT EDWIN PEARY, DISCOVERER OF THE NORTH POLE, WITH HIS DOGS

Flinders Petrie arrived at his discoveries by being his own chief workman. When anything was found, his diggers left it in the soil for him to clear it. After the first week of labour, feeling for delicate things in the earth in a way that no tools can do, the skin of his fingers was almost worn through, and his nails broken down. But by keeping at the job for another fortnight he grew his own gloves, for his skin became so thick that he was able to finger through tons of grit and sand without hurting his hands. Most of the time he lived in a tent upon the edge of a desert,

This was the opportunity for which the Englishman had been waiting. He went over the rubbish-heaps left by the Frenchmen on Abydos Plain, discovered the throne-names of four kings of the First Dynasty, and unearthed the hand-moulded pottery of their people. He even found the toys used by the babies of the Stone Age, and the jewel-box of a chief's wife, ornamented with drawings of fishes and gazelles. The furniture of seven kings was recovered, and pieces of pottery made by the early Cretans. A new vista into the beginnings of what is perhaps the earliest civilisation

was opened up by the things collected from rubbish-heaps left by the Frenchmen.

The work completely changed the current ideas of the general course of development of human society. It is now known that, from the ores used by the early Egyptian women to paint their faces, the art of smelting copper was discovered. Very likely some woman dropped a piece of malachite, or the cosmetic paste prepared from it, into her charcoal fire. The bead of metallic copper so obtained formed the starting-point of the Bronze Age of the world of which Egypt was the inventor. Since Flinders Petrie discovered the first burial-place of the earliest Egyptians in 1894, the work he began has been continued by Dr. Reisner and other excavators, with the surprising result that the earliest Egyptians and the ancient Britons who built Stonehenge seem to belong to the same original stock.

FLINDERS PETRIE
Photograph by Russell & Sons

They formed part of the so-called Mediterranean race, which is seldom more than five feet in height, when still free from admixture with Celts and Northern Europeans. But, like ourselves, the prehistoric Egyptians were afterwards mixed with the Celts, who learned from them how to use bronze weapons, and the historic race of Egypt was formed by an amalgamation of the two races. In his last book, "The Revolutions of Civilisation," Flinders Petrie takes the view that every civilisation grows and decays, so that none can last. He holds that only by intermarriage with a more virile and perhaps more barbaric stock can the people of a highly civilised country win the strength to endure. Such, at least, are the ideas that have occurred to him after working for many years in exploring the strange adventures of the most remarkable race in the world.

AUGUSTUS HENRY PITT-RIVERS
A Tracer of the Evolution of Human Arts

Augustus Henry Lane-Fox Pitt-Rivers, the son of W. A. Lane-Fox, of Yorkshire, was born on April 14, 1827. He adopted the name of Pitt-Rivers late in life on succeeding to the property of Lord Rivers. After studying at Sandhurst, he entered the Grenadier Guards in 1845, fought in the Crimea, and was employed in investigating improvements in the new rifle introduced into the Army in place of the smooth-bore musket. He was the originator of the Hythe School of Musketry. Struck by the fact that modern weapons of war were developed by small and continual changes, and that no far-reaching outburst of inventive imagination suddenly and completely revolutionised a gun or a rifle, the young officer decided to ascertain if this was the general law in all human arts.

So he began collecting the weapons and tools of savages and prehistoric races in 1851. By using a scientific system of classifying the earliest objects of human making, he was able to show that they had all been gradually improved by the same method of small and successive modifications which he had observed in the case of the modern rifle. His collection was the first application of the theory of evolution to the primitive arts of mankind. Exhibited at Bethnal Green Museum in 1874, it profoundly modified all ideas of primitive and savage man, and brought the entire course of arts and industries under the law of evolution. The collection grew so large that Pitt-Rivers was unable to house it. He offered it to the British Government; and when his offer was refused the University of Oxford gladly accepted the magnificent collection, and built the Pitt-Rivers Museum to contain it.

Pitt-Rivers further distinguished himself by being the first man to discover the weapons of the Old Stone Age in Egypt, thus proving that this seat of one of the earliest of civilisations was inhabited by

man many thousands of years before its known history began. But it was in England that the discoverer of the evolution of human arts fully displayed his exploring genius. Under the will of George Pitt, who died in 1828, he succeeded in 1880 to the vast estate of Cranborne Chase, lying to the west of Salisbury. It consisted of 29,000 acres of land, untouched by excavators, and containing part of the primitive forest that had sheltered the first tribes inhabiting Britain. Up to this time nearly all the work of digging up the remote history of our country had been conducted by amateurs, who often destroyed the most valuable evidence in their search for striking objects. Pitt-Rivers was an excavator of the modern scientific school. What he valued above all the vestiges of the prehistoric past were pieces of broken pottery of the most insignificant appearance. Failing these, the absence of pottery in ground that had been most carefully examined was to him a matter of the highest importance. His incomparable knowledge of primitive industries enabled him to use pottery in ascertaining the date and the state of culture of the inhabitants of the villages and earthworks buried under the dust of thousands of years in Cranborne Chase.

He engaged a skilled staff of draughtsmen, anatomists, and excavators, and drove trenches through the ancient forest. He measured the depth at which every piece of evidence was found, and usually photographed each find of importance in the place in which it lay. Very happy were the discoveries he made. The race of Britons inhabiting the Chase was very small in stature. The average height of the women was about 4 feet 10 inches, and that of the men was 5 feet 2½ inches. The Celts had never been able to conquer these descendants of the early settlers. Moreover, after the Romans left, the small, dark-haired forest-dwellers had kept the invading Saxons at bay for a long time, and at last intermarried with them. Pitt-Rivers was able to point out their descendants among the modern population of our country; and later men of science have been able to find some grounds for the idea that these early settlers did not speak a European language, but were related to the Basques who have survived in the Pyrenees. They were probably the first cultivators of the soil of Britain.

Pitt-Rivers built a local museum to contain the valuable materials that he dug up on Cranborne Chase before he died, on May 4, 1900.

MARCO POLO

The Greatest of All Land Explorers

In 1260, eighteen years after the Mongols had established their rule from Poland to China, two Venetian noblemen set out from Constantinople on a trading venture in the Crimea. The Crusaders still held the coast of Syria, and the Christians of Europe, having beaten back the Mongols, hoped to turn these terrible enemies against the Mohammedans. The two Venetian patricians were Maffeo Polo and Nicolo Polo; they were brothers, and Nicolo had married and left his wife at Venice, where, unknown to him, she gave birth to a boy, Marco Polo.

In the Crimea the adventurous merchant-princes found a remarkable opening for commerce. The Mongols, rich with the spoils of half the world, eagerly welcomed them; and by following every opportunity the Polos travelled at last right across Asia, and arrived in China at the Court of the Great Khan, Kublai. The Mongol emperor was delighted with the two Venetians, and much entertained with the tales they told him of European life and inventions. He came to the conclusion that the Christain religion would be an excellent instrument for civilising his savage hordes, and he sent the Polos as his ambassadors to the Pope, asking for a hundred missionaries to convert his people.

The brothers arrived at Acre, in the Holy Land, in April, 1269, and there heard that the Pope was dead, and no successor yet appointed. Two years passed before the cardinals chose a new Pope. In the meantime the Venetian explorers returned to their native city, and Nicolo found that his wife was dead, leaving him a son, the famous Marco, then about fifteen years old. Gregory X. was at last made Pope; but such was the corruption of the Church at the close of the thirteenth century that a hundred missionaries could not be found. Only two Dominicans were willing to risk their lives in converting the Mongols, and they, too, lost courage at the beginning of the expedition, and turned back.

In November, 1271, the two Polos set out from Acre, and Marco, thrilling with youthful zest for the great adventure, accompanied them. The travellers struck out for Bagdad, and, reaching the Persian Gulf, turned northward through Kerman, Khoristan, and Balkh. Crossing the upper Oxus, they went over the Pamir highlands, and

arrived at the awful desert of Takla-makan. Skirting it, they passed by Khotan, and other towns now buried in the sands, and reached Lake Lop—never again seen by Europeans till the nineteenth century—and from there they traversed the great desert of Gobi, and, entering China, reached the Court of the Great Khan in May, 1275.

Kublai took very kindly to Marco, now a young man of twenty-one. Up to this time Marco had owed everything to the courage and experience of his father and uncle. Theirs was entirely the credit for the two most remarkable feats of land exploration known to history, ranking in importance with that of Columbus, and, indeed, directly inspiring him, hundreds of years afterwards, with the idea of his

MARCO POLO

voyage. At the Court of Kublai Khan, Marco began to distinguish himself. He studied the languages and written characters of the diverse races governed by the Mongolian emperor; and partly out of personal liking for the young Venetian, and partly out of admiration for his talents, Kublai appointed him a Government officer.

This part of Marco Polo's story is confirmed by the Chinese annals of the Mongol dynasty. It is therein recorded that in 1277 Polo was made a 'second-class commissioner. In the course of his duties, Marco explored the Chinese provinces of Shansi, Shensi, and Szechwan. Knowing that Kublai delighted in tales of the strange manners and oddities of nations, Marco collected all the curious facts likely to interest the Mongol ruler. He did this especially in his travels through Eastern Tibet and Yunnen, and on returning to Court he rapidly rose in favour. For three years he governed Yangchau, and in his wandering roamed south to Cochin-China.

In the meantime, his father and uncle had been helping the Great Khan in his wars, by constructing for him new and powerful engines of attack. Naturally, the three Venetians became very wealthy while enjoying the friendship of the mightiest ruler in the world. But, when they spoke of returning to Europe, Kublai refused to let them depart. They had become too valuable to him in many ways.

Happily, the fame of the Venetians had spread to Persia, where a great-nephew of Kublai reigned, and he sent to China for a bride of his own tribe. His ambassadors asked that the Polos might also come to Persia, and Kublai at last agreed to this, and gave the Venetians messages to the King of England and other European rulers. As there was war along the land route from China to Persia, the bridal party went by sea, leaving China in 1292. The expedition stayed at Sumatra and Southern India, where Polo collected much information about these unknown parts of the world. It was two years and more before Persia was reached, and the Polos did not regain Venice until 1295.

They came to Venice dressed in Tartar costume, and they had half forgotten their mother tongue. Even their closest relatives refused to acknowledge they were the Polos. But they gave a magnificent feast, dressed in the rich attire of their own nobility, and after dinner they brought out their rough Tartar dresses, and ripped them open, revealing the wealth of diamonds, rubies, emeralds, and other precious stones they had won in their adventures. So their relatives no longer held back from them!

The Polos became famous, and the next year Marco was given the command of a galley in a sea-fight with the Genoese. The Venetians were completely defeated, and, with a multitude of his comrades, Marco was captured and imprisoned at Genoa. A fellow-prisoner from Pisa, who had won some fame as a compiler of French romances for King Edward of England, suggested to Marco that he should dictate the story of his travels in Asia. So Marco spent his term of imprisonment in dictating his adventures to the journalist of the Middle Ages. Released from prison, he returned to Venice, married, and lived quietly

and happily, making his will on his death-bed in January, 1324.

NIKOLAI MIKHAILOVICH PRJEVALSKI

The Greatest Explorer of Central Asia

In spite of the extraordinary progress made by the nations of Europe in many directions in 1870, little was then known about the central regions of Asia. A number of men were ready to risk their lives in the icy wastes of the Poles and the tropical jungles of Africa and South America, but no one seemed to care to follow the path through the enormous desert of Gobi taken by Marco Polo and his companions six hundred years before. Dim traditions of difficulties to which European travellers were unaccustomed no doubt kept back some men; political obstacles damped the ardour of other adventurers; and there were those who thought that the great cost and exceeding peril of exploring the vast, strange wilderness would not be repaid by any results of importance.

As a matter of fact, the expense of the famous expedition that rolled back the curtains of mystery and terror from Central Asia was less than £25. It was undertaken by a young officer in the Russian Army, who merely set out with a couple of companions in search of sport. Happily, he was a first-rate geographer as well as an enthusiastic hunter. Getting well into the sea of sand in pursuit of new game, he found that with courage and endurance a white man could make his way from oasis to oasis as safely as a native tribesman. So he stayed there for thirty-four months, covered 7320 miles, and accomplished the most remarkable journey through Asia in modern times.

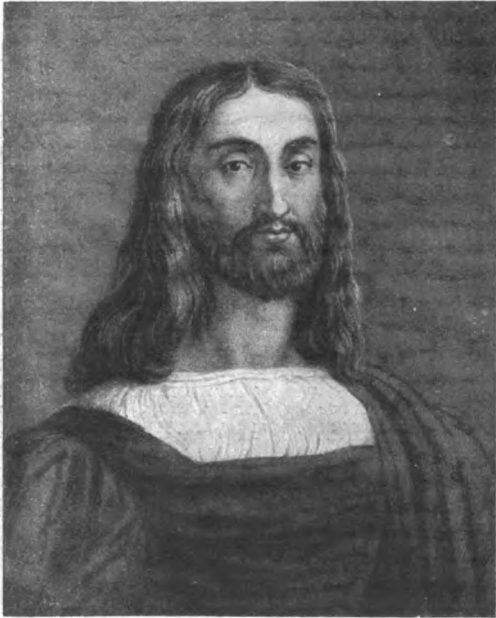
If it were not for the difficulty of pronouncing his name, Nikolai Mikhailovich Prjevalski would be as world-famous as Livingstone or Stanley. He is, indeed, the Stanley and Livingstone of Asia, one of the greatest explorers of all time. Even Hedin has merely followed where he led. He came of an old Cossack family settled at Kimbory in the government of Smolensk. Born on March 31, 1839, he lost his father at an early age, and was taught by his mother. As a boy he hunted in the forests of Smolensk, and there acquired that passion for sport that afterwards made him an explorer. As a Cossack noble he was born to a military career, and at sixteen he became a subaltern, and next year an officer. Entering the Academy of the General Staff, he took up the study of geography, and distinguished himself by a dissertation on the Amur region, the scene at that time of the rapid and continuous forward movement in Russian expansion.

He naturally hoped that his work would lead to his being sent to the land of adventure he had especially studied. But to his disappointment he was made a teacher of geography at a military school at Warsaw. But this apparent check to his ambitions was a fortunate thing. His new field of work made a man of science of him, and gave him the training and the knowledge necessary in his future exploring expeditions. At last, in 1867, he was given a position on the General Army Staff, and sent to Irkutsk, and he began the great work of his life by exploring the Usuri, a southern tributary of the Amur. Then in November, 1870, he set out on the hunting raid that brought him all the adventure he longed for, and more fame than he ever dreamed of. He roamed from Pekin to Tibet, crossing the Gobi Desert twice, discovering the wild camel amid the waste of sands, and the wild yak among the mountains of Northern Tibet. He reached the source of the Yang-tse-Kiang, and was within a month's march of Lhasa, when the conditions of his camels and the state of his funds compelled him to return.

In 1876 he struck out from Russian territory into the terrible Takla-makan waste. This is really the western extension of Gobi, but it is much worse than the larger and more famous of Asian deserts. It is a region of death—a sea of huge sand-waves in which not a gnat can live for want of water. Following the River Tarim, that skirts the northern edge of the lonely wilderness, Prjevalski came to a wide marshy lake where all the water ended. It was the ancient and mysterious Lob-nor, the lake seen by no European since Marco Polo. Century by century it has grown salter and smaller, and it is now a marsh, that strangely changes its position, rather than a body of water. For thousands of years the rise and fall of the water in this strange, withdrawn desert lake formed the pulse of the world. For at each fall the thirsty, starving tribes of Central Asia migrated, and fell in wild, fierce, predatory hordes on the civilisations of the Eastern and Western world.

On his third expedition, in 1879, the Russian explorer found the wild horse in the desert of Dzungaria, a kind of outlying arm of the great Gobi. He also came across more wild camels. Among the other new animals he found in the course of his

explorations were an unknown variety of antelope and a new kind of sheep, while the wild yak was often met by him. In his third journey he collected 4500 birds, fishes, and mammals, and 6000 insects. On this occasion he travelled 14,700 miles. He crossed the western Gobi, explored South Tsaiden and Mongolia, and marched on Lhasa. But when he was within 170 miles of the Holy City of Buddhism he was turned back by the lamas.

His last expedition set out in 1883 from Urga. Crossing the Gobi in its wildest part, he turned southward in 1884, and reached the sources of the Hoang-ho in a region known to Chinese geographers as the Sea of Stars. It lies among the mountains on

MARCANTONIO RAIMONDI

the north-east of the Tibetan tableland—a tussocky marshland dotted with small lakes, and showing signs of having once been the bed of an inland sea. It was the first time that a European had seen this remote and secluded country. Prjevalski then went back to the Lob-nor Desert, and completed his earlier survey of the strange, vanishing sea. He returned west by the desolate Kuen Luen mountain range, and struck into the Takla-makan wilderness at Khotan, and discovered a double row of heights in this terrible desert. Raised to the rank of general by the Russian Government, and honoured by learned societies throughout the civilised world, Prjevalski began his fifth journey in the autumn of 1888, intending to penetrate to Lhasa, but died at Karakol on October 20, 1888.

MARCANTONIO RAIMONDI

A Modern Explorer of Peru

Until quite recently more than half of the territory of Peru was unknown land. Consisting of wild, mountainous country, stretching eastward from the lower slopes of the Andes, its dense primæval forests shut out the forces of civilisation. The forest had stayed the power of the ancient Incas; it had resisted the Spanish colonists, and at the middle of the nineteenth century it was sparsely peopled by scattered bands of wild Indians, and as mysterious as Central Africa.

The Peruvians had no passion for exploration; they were busy enriching themselves by the exploitation of the resources of the coast lands. It was an exile from Italy, Marcantonio Raimondi, who took up the task of discovering regions of Peru that had remained unknown from the dawn of American civilisation. Born in Milan, in 1826, Raimondi in his youth studied medicine and various branches of science, and threw himself eagerly into all the patriotic movements by which the Lombards sought to free themselves from the yoke of Austria. But after the disastrous battle of Novaro, in 1849, he joined the stream of Italian refugees who settled in South America. His distinguished gifts were appreciated by the Peruvians, and he was made professor of medicine at Lima, and for twenty years he also occupied the Chair of Natural History in this famous town. In intervals of leisure between his work of teaching he studied the geology, geography, and natural history of his second fatherland, and thus prepared himself for the great achievement of his life—the scientific exploration of the large unknown tracts of land in Peru.

He began in the province of Caraway, renowned for its gold-mines. Travelling on foot, he mapped out the various streams descending from the Cordillera Nevada. No one at that time knew in what direction these waters flowed, or what tributary of the Amazon they swelled. In each of the deep gorges through which he adventured Raimondi found distinct and peculiar kinds of birds, insects, and shells, showing that in these lonely gashes in the mountains the evolution of life had proceeded for ages on new lines. He proved, in fact, that mere isolation was an important factor in the origin of species.

After mounting from the tropics to the snows, he crossed the Andes, and descended to the steaming heat of the lower slopes. So thick was the growth of palms, tree-ferns, and trees that in places the explorer walked in darkness, though the sun was blazing in tropical splendour on the matted roof of foliage above his head. Here began the extraordinary forest of South America, stretching without a break from the Andes to the Atlantic Ocean. A much-dreaded tribe of savages—the Chuncos—roamed the strange twilight land. After studying the Peruvian portion of the Amazon, Raimondi, in 1866, turned southward and investigated some of the chief tributaries of the Ucayali. He found that even in the dry season small steamers could go 1022 miles from the mouth of the Ucayali.

Owing largely to the fine pioneer work of Raimondi, the Peruvian Government began to encourage explorers to adventure into the great forest, in the hope that they would discover a short commercial route to Europe by way of the Amazon and the Atlantic. Raimondi himself was able to give more time to collecting and arranging the materials he and other men discovered. His own explorations and researches covered almost every part of the republic, and out of them he began to build a monumental work, entitled "El Peru." But during the war between Chili and Peru large portions of his manuscripts were destroyed, and when he died, on November 1, 1890, only the first three volumes had been published.

SIR WALTER RALEIGH
A Founder of the British Empire

Sir Walter Raleigh, whom Dean Stanley termed "the father of the United States," and who certainly was a founder of the British Empire overseas, was born at Hayes, near Budleigh Salterton, South Devonshire, in, it is believed, 1552. His father, head of an ancient house, which was connected with many distinguished Devon and Cornwall families, had married, as his third wife, Katherine, daughter of Sir Philip Champernowne of Modbury. She was already a widow, and mother of Humphrey and Adrian Gilbert, who were thus stepbrothers to Raleigh. The name of Raleigh, by the way, is known to have been written in some seventy different ways. The popular spelling, which is here adopted, is said never to have been used by Sir Walter.

SIR WALTER RALEIGH IN THE TOWER OF LONDON, AT WORK ON HIS HISTORY OF THE WORLD

As a boy, Raleigh was devoted to literature, as indeed he was all his life, but there is historic foundation for the charming picture of Millais which represents him sitting, as a handsome lad, listening with rapt attention to the story of some hardy adventurer who had returned from distant voyages overseas, who had to tell of strange waters so thick with fish as to impede the progress of the little, half-decked ships in which Englishmen went out; of lands seamed with gold and silver, whence the wicked King of Spain derived his wealth, and of many a stirring adventure beyond that wondrous Western Ocean.

The spirit of adventure leapt up in the

heart of the boy, and he had barely passed through Oxford when, at seventeen, he was off to the wars to strike a blow for his religion under the Huguenot flag in France. It is stated, on doubtful authority, that he was in Paris on the day of the Massacre of St. Bartholomew. We know that he accompanied Sir Humphrey Gilbert's unsuccessful expedition of 1578, an expedition nominally for the purpose of exploration, but in reality a privateering adventure. He first becomes an important figure to us when he appears in Ireland in command of a troop sent to help put down the rebellion raised by the emissaries of Spain. He assisted gallantly at the capture of the fort, and took part in the proceedings in which the garrison, to the number of six hundred, were put to the sword. The presence of this hostile force in Ireland, when England and Spain were at peace, affords an interesting sidelight upon the actual relations between the two countries, and explains, as no argument could, how it was that Drake and Frobisher, and Raleigh himself when at sea, behaved as pirates. This Spanish garrison in Ireland consisted of pirates, and the history of their foray may well be read in conjunction with the reply made by Elizabeth (in the life of Drake) to the Spanish ambassador's complaint after the return of Drake from his circumnavigation of the globe.

The story told by old Fuller of Raleigh's introduction to Queen Elizabeth, of his spreading his gorgeous cloak to guard her from the mud is, to vary a Scots verdict, "not disproven." But, whatever the fact as to his introduction, there is no doubt as to the high position in the esteem of that susceptible sovereign to which he at once advanced. He presented a splendid figure, with his dark hair and fine colour, and his graceful, lofty bearing. He was renowned for valour and high courage as well as for prudent counsel; and these qualities, with his wit and eloquence, allied to a facile and graceful pen, made him the beau-ideal of a courtier. Elizabeth heaped honours and emoluments upon him, made him captain of her guard, gave him great estates in England and Ireland, and presented him with rich monopolies. But she kept him ever near her person, and would not allow him to undertake personally any of the oversea ventures he was constantly planning. If he could not go in person, he put money into the ventures of others; and many a good guinea of his went to that operation in which Drake delighted, "singeing the King of Spain's beard." He had in this way a principal share in establishing the Newfoundland colony which cost Sir Humphrey Gilbert his life, and he himself sent out the expedition which surveyed, and in the Queen's name took possession of the territory which she herself named Virginia.

The story of that colony need not be recalled at this place. Raleigh spent £40,000—at least a quarter of a million of our currency—upon the scheme, and did not live to witness its success. But he had given England an idea and an ideal—that of Britain beyond the seas. Since Raleigh's day the British Empire has increased by over eleven million square miles, but the colony that he founded was one of the first territories over which the English flag ever flew other than the impossible provinces we once held in Europe. Calais, our last stronghold on the European Continent, passed from us with the reign of Mary; in the reign that followed we colonised part of America by way of compensation, just as in later days we were to possess ourselves of Australia in place of the lost United States, of which Raleigh was truly the father.

One of the material comforts that Raleigh derived from his enterprise resulted from the bringing home by his servant of the first potatoes and tobacco received in this country. Drake, it is true, had brought to England some few leaves of the weed, but Raleigh smoked it, popularised it at Court, and was, without doubt, drenched by his servant who entered his room to find his master, pipe in mouth, apparently on fire. Raleigh himself cultivated the potato on his Irish estate, so bestowing an inestimable gift on Ireland. The first English potatoes seem to have been grown in the Strand, in the garden of Lord Burghley, to whom some were given by Raleigh.

A cloud now appeared upon Raleigh's horizon. A new star arose in the Court firmament—Essex, bold, insolent, haughty; and he, gaining the place of the former favourite, caused his withdrawal to Ireland, where he was consoled by the friendship of Spenser, who celebrated him as the "Shepherd of Ocean," and was borne by Raleigh, restored to favour, to the presence of the Queen. Raleigh took an active part in raising the country in anticipation of the Spanish Armada, but there is considerable doubt as to the part he actually played in the fighting. There never stepped a more valiant defender of our land than Raleigh, but there never was a more insistent Queen to keep a gallant man at home.

Raleigh's next disaster arose from the discovery of his liaison with Bessy Throgmorton, one of the Queen's beautiful maids-of-honour. Both the lovers were thrown into the Tower, where Raleigh was kept prisoner for four years, only regaining his liberty in order that he might safeguard a rich Spanish prize from the rapacity of his fellow Devonians upon its being taken into Dartmouth. He eventually married Bessy Throgmorton, but sailed to Guiana, explored Trinidad, and the Orinoco for some hundreds of miles, and returned with stirring stories of the tropical splendours of the scenes he had witnessed, and of inexhaustible stores of gold. He had a glorious part in the action against Cadiz, and in the expedition of 1597 against the same enemy at the island of Fayal, which Raleigh captured before his leader, Essex, arrived.

Raleigh was gradually restored to favour, sat in Parliament, and nobly defended religious liberties. Macaulay's picture of him in his prime relates to a time slightly earlier than this, but it is worth recalling here as bringing into sharper contrast the scenes that were to follow: "Raleigh, the soldier, the sailor, the scholar, the courtier, the orator, the poet, the historian, the philosopher, whom we picture to ourselves sometimes reviewing the Queen's guard, sometimes giving chase to a Spanish galleon, then answering the chiefs of the country party in the House of Commons, then again murmuring one of his sweet love-songs too near the ears of her Highness's maids-of-honour, and soon after poring over the Talmud or collating Polybius with Livy." But dark clouds gathered about him with the accession of James I., whose mind was poisoned against him by the crafty Cecil and the faithless Lord Henry Howard. He was stripped of his offices and the bulk of his possessions, declared to have conspired to set Arabella Stuart on the throne, tried, found guilty, and sentenced to death upon charges as baseless as ever imperilled the life of any man. In vain was Raleigh's noble and eloquent defence, a defence which caused Dudley Carleton, who heard the trial, to say that when it began he would have gone a hundred miles to see Raleigh hanged, but ere it was closed he would have gone a thousand to save his life.

Raleigh was reprieved on the scaffold, but kept a prisoner in the Tower for fourteen years. There the only worthy member of the Stuart family, Prince Henry, visited him. "No man but my father would keep such a bird in such a cage," the amiable young Prince declared. For Prince Henry, Raleigh modelled a ship; for him he composed moral and political discourses, and began his noble "History of the World." Raleigh ceased the work with the death of the Prince, and the "wisest fool in Christendom" stopped its sale, on the ground that it was "too saucy in censuring·the acts of kings." Yet it only comes down to 130 B.C.! After fourteen years of imprisonment, during which the greatest scientists and wits of the age visited and cheered him, Raleigh was released to carry out another expedition to Guiana. The expedition was a failure. He did not discover his gold-mine, though it existed and has since yielded millions. To compensate for his disappointment he sought to enrich himself, as was the custom, at the expense of a Spanish settlement. James was conciliating the traditional enemy, and made Raleigh's foray the pretext for putting into execution the death sentence passed fifteen years earlier. Raleigh accepted his doom with absolute composure and fortitude, and, reproved for his high spirits, said, "It is my last mirth in this world; do not grudge it to me." Raleigh was beheaded in Old Palace Yard on October 29, 1618. To one who objected, as he knelt at the block, that he should lay his head towards the east, he replied, "What matter how the head lie, so the heart be right?" Than which, says Gardiner, no better epitaph could be found for him.

SIR HENRY RAWLINSON

An Explorer of the Dead Past

Henry Creswicke Rawlinson was born at Chadlington, Oxford, on April 11, 1810. At seventeen he sailed for Bombay as a cadet of the East India Company. It chanced that on board his ship was Sir John Malcolm, a governor of the company, and a prodigious linguist. To his good offices the friendly relations between Persia and England were largely due. Rawlinson was fired by the conversation of his chief to emulation, became deeply interested in Persian lore, and showed himself marvellously adept in the acquisition of Persian and the Indian dialects. Among the student interpreters of our Foreign Office staff are many youthful marvels of learning, and it sometimes happens that a man, star-bespangled with half the Orders of Europe in commemoration of embassies at the great Courts, has half the vernacular tongues of the romantic East at the back

of his tongue. Rawlinson was an early and notable example of the type. Fortunately, Rawlinson specialised less, confining himself more particularly to Oriental tongues. He obtained a notable mastery of the ancient with the modern; and as to the latter, Arminius Vambéry, himself a prince of polyglots, says, describing an interview with him, "Although I was able to lead an English conversation, still, for the sake of fluency, I preferred Persian, of which Sir Henry was a perfect master, and which he handled with exquisite refinement."

Rawlinson became an interpreter at the end of his first year's course, and distinguished himself by his smartness as a

A WINGED HUMAN-HEADED BULL, BROUGHT FROM SARGON'S PALACE BY SIR H. RAWLINSON

soldier and horseman. He made a famous ride of 750 miles in 150 hours to carry important news to Teheran. He showed himself a brilliant military organiser and fighter, and a talented diplomatist; helped to reorganise the Persian military forces, held civil appointments at the Courts of the Shah and the Sultan, and, sent to Kandahar, maintained British influence throughout the period of the massacre, and of Pollock's punitive expedition. These matters, together with his career in Parliament and his work as Persian ambassador, belong, however, to the main stream of nineteenth century history. We are concerned here with his work as an explorer, and that not so much as an explorer of territory as of the fascinating domain of dead history.

Layard unearthed the monuments of the past; Rawlinson gave them speech and language, made dead giants live, and Biblical figures declare themselves anew in the very words they had uttered for commitment to stone twenty, thirty, and forty centuries before. His interest in the work was aroused by his explorations first in Susiana, and afterwards through Persian Kurdistan; and it is worth noting that it was his desire to prosecute researches here that caused him to take the post of political agent in Turkish Arabia, and that of consul at Baghdad. The lodestone was the remains of Baghistan, now called Behistun, or Bisutun, the ancient Persian city some score of miles east of the modern Kirmanshahan. Here stands the famous precipitous rock which rises on one of its sides perpendicularly to a height of 1700 feet, and had been noted from ancient times as bearing upon its surface a vast series of mysterious figures and signs. The Greeks had attributed it to Semiramis, but there it stood in Rawlinson's day as it had stood for twenty-three centuries, a challenge to modern learning, a pathetic memento of a vanished culture.

Three hundred feet above the base, on a polished surface, is sculptured a bas-relief representing, Rawlinson has taught us, Darius Hystaspes, conqueror of Babylon and hero of victories as far divided as the Caucasus and the Indus—the great monarch under whom began the war between Persia and Greece which included the battle of Marathon. The bas-relief depicts him receiving the homage of a long row of fettered captives, representatives of the subjugated nations. This bas-relief is surrounded by numerous columns of inscriptions, making in all over one thousand lines of cuneiform writing. The account of Darius's reign is repeated in three different languages of the empire, Persian, Assyrian, and the language of Susiana (Elam). What did it all mean? Here was treasure inestimable, if it could be but deciphered. All clue to the dead tongues as here expressed had been lost.

During a long period of thrilling dangers, privations, and hardships, Rawlinson copied and puzzled, and sent home his tracings to the scholars of England. There was no one in Europe who could make head or tail of the matter. But there happened to be in the service of the East India Company a humble clerk named Norris, who had taken up as a hobby a study of the cuneiform

outlines. To him they were drawings, pictures, to be systematised and carried in the mind's eye. When he saw Rawlinson's copies something struck him as unfamiliar. His eye sought a certain shape of outline, a certain sequence of strokes, and failed to find them. Although he had never been outside his native London he felt that the copies before him were not accurate copies of the inscriptions on the age-old pillar of Behistun. Rawlinson's attention was drawn to the humble student's modest suggestion; he went over his work again, and found that the unknown London clerk was right—he had made blunders.

Probably the incident has no parallel save in the case of the printer with the paralytic arm who, as he set up the pages of Max Müller's "Rigveda," noted certain errors and neatly marked them as he pulled his proofs. Müller at first thought that some professor learned in Sanskrit was overseeing his work; but no; the emendations were traced back to the compositor. "Do you know Sanskrit, then?" asked the scholar. "No, sir," he was answered; "but my arm gets into a regular swing from one compartment of types to another, and there are certain combinations that never occur. So if I have suddenly to take up types which involve a new movement, I feel it, and I put a query." The palsied arm of the printer kept the greatest of philologists from straying, and the clerk in a London office kept the father of Assyriology from committing the like offence.

Rawlinson threw himself heart and soul into the work of deciphering the baffling inscriptions, and, by a process as romantic as that which led Young and Champollion to the secret of the Rosetta Stone, he made out an alphabet, he spelled out the secret of ages, he gave the world the story of Darius as inscribed by himself twenty-three hundred years before. Assyriology was born and placed upon a scientific basis. At the beginning of the ninteenth century the languages and histories of Egypt and Assyria were sealed books to mankind; to-day nearly every great university in Europe and America has its Chair for both subjects, and the story of the buried past is now a volume which he that runs may read.

There were others in the field at about the time that Rawlinson was engaged, but his claim to priority is clearly established. It was a thrilling and romantic moment for the world when an undeciphered inscription of Tilglath Pileser, submitted independently to four disciples of the new learning, produced practically identical translations. The work of Layard would have been deprived of 90 per cent. of its value but for the labours of Rawlinson, whose efforts are frequently mentioned in the writings of the man who dug up the buried cities. Rawlinson himself carried on the excavations at Birs Nimrud, the traditional site of the Tower of Babel, which stood at the south-west corner of the area covered by ancient Babylon. With the knowledge that he had pieced together he tore its mystery from its stones, and read the tale of the wonderful origin of the fabled site. The building, he showed, was once the world-famous Tower of the Seven Planets, built upon an ancient site of a temple by Nebuchadnezzar in the sixth century B.C. The tale-bearing cylinders are now in the Babylonian room at the British Museum, where we may all read the translations of the master-hand. If only those translations were cheaper!

Other work by Rawlinson included the unearthing of the ruins of Nebuchadnezzar's palace. But it was the deciphering of the writings and inscriptions, not so much their discovery, which made him so great an asset to the learning of the world. Only a hint has been given here as to the difficulties, dangers, and hardships in which his work was conducted, but there is a suggestive little touch in a note relating to his translation of the Nineveh inscriptions, which he describes as being done in great haste, "amid torrents of rain, in a little tent upon the mounds of Nineveh, without any aids beyond a pocket Bible, a notebook of inscriptions, and a tolerably retentive memory." Rawlinson's fourfold career as warrior, explorer, diplomatist, and Assyriologist made him a very notable figure of his era. He died in London on March 5, 1895, having four years previously been created a baronet.

BARON FERDINAND VON RICHTHOFEN

The German Explorer of Inland China

When a well-trained geologist sets out to explore a country, he looks mainly to its mineral treasures. By combining the zest for exploration with the science of the structure of the earth Baron Ferdinand von Richthofen became the supreme authority on China during the last quarter of the nineteenth century, and it was probably on his knowedge that the German Government acted in Chinese affairs. From his return to Europe, in 1873, to his death, in 1905, Richthofen was the master of Asiatic geography, and men of the calibre of Sven

Hedin were trained and directed by him. He made Berlin the bureau of information for the whole continent of Asia.

Born at Karlsruhe, in Silesia on May 5, 1833, Richthofen was educated at Breslau and Berlin, devoting himself especially to geography and geology; and in 1856 he made an important contribution to the study of the mountains of the south-eastern region of Tyrol. This led to the offer of a position, under the Austrian Government, at the geological institute in Vienna. Here the young man of science worked for four years, acquiring the practical knowledge and experience which were to be afterwards applied to the problems of the Far East.

BARON FERDINAND VON RICHTHOFEN

It was in 1860 that he won the opportunity he longed for. A Prussian mission was sent to Eastern Asia, and Richthofen accompanied it. He visited Ceylon, China, Siam, the Philippines, and Java, but owing to the Taiping rebellion he was unable to explore the Chinese Empire. The other members of the mission returned to Berlin, but Richthofen was touched by the magic of the Orient, and stayed behind. He had lost his notes and collections, and he was resolved not to go back empty-handed. He wandered about India for a little time, and then went to California and Nevada, and studied the gold-mines there from a geological point of view. He wrote in good English a work on the famous Comstock Lode, which was published in San Francisco in 1865.

Three years afterwards he came to Shanghai, and, finding that the domestic affairs of China were fairly peaceful, he set out on the great work that he had long wished to undertake. He seems to have approached the Shanghai Chamber of Commerce for help in his undertaking, and during his wanderings he sent them a series of very valuable reports on the mineral wealth and general commercial activities of most of the provinces of the Chinese Empire. He spent four years in China, and for most of this time his only companion was his interpreter. By tact and charm of manner he kept on friendly terms with the strangely diverse races of China, and, travelling from province to province, he studied in a scientific manner the lie of the land and the structure of the earth, and solved most of the chief problems of Chinese geography. As a rule, he found that the surveys done by the Jesuit missionaries were good, but there were vast tracts of country—such as the Nanshen Mountains, covering as much space as France and England—which he was the first man to describe in an exact manner. Exactness of description was indeed his aim, rather than the discovery of unknown regions. He wanted to put both the geological and geographical knowledge of China on a foundation of exact facts. This in large part he did, with the result that he became the father of East Asian geography.

Before his exploration, the mountains and smaller rivers of China possessed a curious power of locomotion. This was especially the case on maps drawn by men interested in proposed railways. The hills skipped like sheep, and awkward streams kindly flew away from the projected route, so that the work of construction might not seem costly. Richthofen introduced a natural fixity into the large feature of the Chinese country. Then, going deeper, he revealed the underlying strata of the land, and indicated the depths where unexploited coalfields and ores would probably be found. His work was both thorough and extensive. He visited ten of the principal provinces, and made detailed geological exploration of the regions around Nanking and Chinkiang. But as he was going southward to Yunnen, in 1872, among the wild tribes, he was attacked and robbed by some soldiers and forced to return.

He regained Europe in 1873. The remarkable value of his achievement was at

once recognised, and he was appointed president of the Geographical Society of Berlin. A professorship was offered to him at one of the German universities, and later on he became the head of a famous school of physical geography at Berlin. The geology of China was the subject in which he specialised, but he exercised a large authority over the development of geography of Eastern and Central Asia. He died October 6, 1905.

SIR JAMES CLARK ROSS

Discoverer of the North Magnetic Pole

Admiral Sir James Clark Ross was born in London on April 15, 1800, and at twelve years entered the Navy under his uncle, Sir John Ross, the famous Arctic explorer. For the next six years he was in various ships commanded by his kinsman, and accompanied him on his first voyage in quest of the elusive North-West Passage, a stern beginning for a lad of eighteen. Little was done, but one of the company, William Edward Parry, a Bath doctor's son, who had joined as a first-class volunteer, showed so much initiative, originality, and independence of opinion that, upon his return, this same Parry was at once appointed to an independent command, and between 1819 and 1827 he led four expeditions to the frigid North. Young Ross accompanied him on each trip. With Parry he reached the point at which waited a Government reward of £5000—for the first man to touch 110 degrees west longitude of America, but under the same gallant commander he came to grief when their little vessel, the "Fury," was smashed up by ice in Regent's Inlet. However, he was not born to die on that day.

He joined his uncle in the splendid expedition of 1829-33, being by this time promoted to the rank of commander of the little ship "Victory," and, in a very fine bit of sledging work on the coasts of Boothia and King William Land, discovered, in 1831, the North Magnetic Pole. Two generations were to pass away before the South Magnetic Pole was located. Following this success, Ross was employed for three or four years upon the magnetic survey of Great Britain, and then, in 1839, began his successful work at the other side of the world.

Proceeding South, in 1839, in the ships "Erebus" and "Terror," he crossed the Antarctic Circle in 1841, discovered and named Victoria Land, and in that region of eternal ice and snow found a mighty volcano in eruption, pouring forth molten lava and red-hot ashes from the fiery heart of a land in which the surface temperature never rises above freezing-point. Although Ross charted as rocks submerged ice over which the sea was breaking, and figured land where, as has since been found, land was non-existent, his expedition gave a great impetus to Antarctic exploration, and he well deserved the knighthood bestowed upon him when he returned. In the same year, 1843, he married, and pledged himself to certain restrictions in the matter of further hazardous explorations. It was due to this pledge that he had to decline the leadership of the expedition in which Sir John Franklin afterwards perished. But,

SIR JAMES CLARK ROSS

whatever may have been the nature of his family undertaking, Ross fared North once again, in 1848-9, in quest of the lost leader, who had gone North in the very ships in which he had come back from the South.

Ross, who rose to the rank of admiral, remained to the last a foremost authority to be consulted in all matters of Polar exploration. He died at Aylesbury on April 3, 1862. He was an inspired leader of men in exploration, and during the four years' trip to the South he lost but one of his company. Like his uncle, he made a miscalculation when he declared that the towering ice-cliffs of the Antarctic continent would for ever bar the way to the South Pole. Still, Ross reached 78 deg. south,

and got to within 160 miles of the South Magnetic Pole, a fine achievement for a man whose equipment was limited by the methods of the first half of the last century.

SIR JOHN ROSS

A Pioneer of the North-West Passage

Sir John Ross, rear-admiral and Arctic navigator, was born at Inch, Wigtonshire, on June 24, 1777. He was entered for the Navy at the age of nine, but, while keeping his name on the books of his first ship, bound himself apprentice on board a merchant vessel to gain experience. Returning to the Navy at twenty-two, he fought with distinction in the war with France, being, it is said, thirteen times wounded. Although he rose to the rank of rear-admiral, he is of note today chiefly from his efforts to find the oft-sought North-West Passage.

His first expedition was undertaken, in 1818, in the whaler "Isabella," accompanied by the "Alexander," of which Parry, his subordinate, was in command. The order was to find a North-West Passage by way of Davis Strait and Lancaster Sound. The route seems open and simple from that deceptive guide the common altas, but never was key forged with such difficulty and suffering as that to this still impracticable channel. That men should wish to attempt the feat at all is in itself a remarkable tribute to the innate heroism of the race. All that men had experienced in the desolate wilds was of a character to make the average sailor wish to keep his toes near the cinders at home; but the Rosses and the Parrys and the Franklins, the Cooks, the Davises, and Baffins, were never happier than when pitting their daring and endurance against the terrible forces of Nature in their most pitiless guise.

What was the nature of the challenge that these heroes accepted? Perhaps no more interesting picture could be suggested than that which rises to the mind from the quaint title-page of the book of the doughty Dutchman Barents. The English translation runs as follows: "The true and perfect description of three voyages so strange and woonderful that the like hath never been heard of before. Done and performed three yeares, one after the other, by the ships of Holland and Iceland, on the north sides of Norway, Muscovia, and Tartaria, towards the kingdomes of Cathaia and China, showing the discoverie of the straights of Weigates, Nova Zembla, and the country lying under 80 deg., which is thought to be Greenland [it was Spitzbergen], where never any man had bin before; with the cruell beares and other monsters of the sea, and the unsupportable and extreme cold that is to be found in those places. And how that in the last voyage the shippe was so enclosed by the ice that it was left there. Whereby the men were forced to build a house in the cold and desart country of Nova Zembla, wherein they continued ten months together, and never saw nor heard of any man, in most greate cold and extreame miserie; and how after that, to save their lives, they were constrained to sail over 350 Dutch miles, which is above 1000 miles English, in little open boates along and over the maine seas, in most great daunger; and with extreme labour and unspeakable troubles and great hunger." That was the kind of true and lively narrative upon which our heroes were nurtured, and by which, in 1818, the British Government, now that Napoleon had been finally crushed, proposed to renew the quest for an open seaway round the northernmost coast of the American continent to Asia and the golden East.

Ross sailed for Baffin's Bay in 1818, and explored it. The map of this part of the world is a permanent record of the perplexities and errors of the men who have sought to fill in its blank spaces, and Ross was destined to commit one of the strangest errors of all. Baffin's Bay is no bay; it is a sea, 800 miles long, with an average breadth of 280 miles, and is frozen from shore to shore for a considerable period of the year. It communicates, by way of Davis Strait, with the Atlantic, and, by way of Smith and Lancaster Sounds, with the Arctic Ocean. Ross found the people nearest the Pole, but he could find no northern outlet to the bay. He turned westward, therefore, into Lancaster Sound, which is one of the gateways of the North-West Passage. And there one of those strange mistakes which have so often occurred in these high latitudes was made. Clouds or some form of mirage obscured the sound, and, misled by their singular appearance, Ross took them to be a huge range of mountains spread inexorably across his path. He put his ship about, and came home, to report Lancaster Sound a land-locked bay. His clouds he named the Croker Mountains, and fully described them in a narrative published in 1819.

Now, with him on the expedition were Parry and a young sailor scientist, Captain (afterwards Sir) Edward Sabine, whom we meet in the biography of Tyndall. Sabine

was astronomer to the party, and, with Parry, was not convinced that the Croker Mountains had any existence outside the imagination of his leader. When Ross's work appeared, Sabine challenged the mountains, as Parry had already done. Parry, indeed, was so confident that the Admiralty had even now sent him out on a further expedition. This impeachment was a bitter humiliation to Ross, but it was all for the good of knowledge, for the way from the East to the West, from the New World to the Old, lies through the very sound which he declared to be barred and sealed by a mountain range. The very controversy thus provoked stimulated inquiry and exploration, and it was by Lancaster Sound, in the end, that Franklin and his comrades went to their doom.

Ross was at last convinced, and yearned to redeem himself, but not until 1829 did he get an opportunity, when, contributing £3000 of his own, he was given command of the expedition fitted out mainly at the cost of Felix Booth. His vessel was the little "Victory," notable as the first craft that ever attempted to steam through the North-West Passage. Ericsson built her engines, and a strange story attaches to their failure. Ericsson knew Ross as a naval officer, and, the meaning of his mission being kept a secret from even the engineer, Ericsson thought the "Victory" would be manœuvring in home waters, whence she could easily reach him for alterations. He therefore put into her the first marine engines built below the water-line. He thought she was a little warship, and treated her as such. The engines were a failure in the "Victory," but they have since been successfully installed in every other warship in the world. Ross, keeping his own counsel, had the engines geared up to hopelessly unsuitable paddle-wheels, of which Ericsson knew nothing. He blamed Ericsson for the failure of the scheme, but the inventor retorted hotly that he had been deceived as to the purpose of the vessel, and that Ross's gearing and paddle-boxes were "a perfect specimen of ignorance of the laws which should be consulted in the construction of bodies intended to move through the water."

However, the first marine engines to go to the Far North remained there. Ross had them cast into the ocean; and in some post-glacial day they may be discovered at the bottom of an erstwhile frozen sea, to prove to an astonished world that the ancient Eskimos of the nineteenth century had advanced ideas on steam navigation. Mechanical propulsion failing, Ross trusted to wind and sails and the drifting of currents. He made no second mistake about Lancaster Sound, but failed to get beyond the ice into Barrow Strait, so turned south-west into Prince Regent's Inlet, and sought in vain to break through by that route. He was caught by the ice, and his ship imprisoned, during the winter of 1829-30, in Felix Harbour. The summer carried him only a few miles south, and the second winter was spent in Victoria Harbour. There the little vessel remained tightly held throughout the summer of 1831, and, of course, the winter of 1831-2. In May of 1832 Ross was compelled to abandon her, and march to Fury Beach, where his nephew and Parry had been wrecked in the expedition of 1824-5. The ruined "Fury" remained on shore, and from her timbers the party constructed a hut, and there spent their fourth successive winter in the ice. In the following summer they made their way on foot to Lancaster Sound, and to their joy found a whaler. It was Ross's old craft, the "Isabella," in which he had made his first voyage to the North. In this the expedition returned, reaching England in October, 1833, after an absence of four years.

Although the voyage did not achieve the Passage, it was highly important in results. The Gulf and Land of Boothia, named in compliment to the London distiller who had financed the expedition, were thoroughly surveyed; King William Land was explored, and the younger Ross determined the position of the North Magnetic Pole. Ross had nobly atoned for the blunder of the Croker Mountains. He had laid useful foundations for Franklin; and when Franklin was lost, the valiant old hero, then threescore years and twelve, was the first to set out to seek him. In the teeth of the opposition of the Admiralty he fitted out a small vessel, named the "Felix," from funds raised by public subscription and a grant from the Hudson's Bay Company. In May, 1850, he set out from Stranraer, and made his way to Lancaster Sound. He failed, however, to glean any tidings of the ill-starred party, and returned in the following year. He died in London on August 30, 1856. The one mistake of his career involved him in bitter controversies to the end of his days, bringing him into conflict with men whom he would not forgive, but his quarrels had the effect of keeping interest alive in the North-West Passage, and of stimulating others to effort.

CHOICE AND MASTER SPIRITS OF THEIR AGE

JOHN MILTON, THE IMMORTAL FIGURE OF THE PURITAN AGE, DICTATING TO HIS DAUGHTERS

SIR THOMAS MORE, THE CATHOLIC MARTYR, CHAMPION OF LIBERTY OF THOUGHT

THINKERS

W. E. H. LECKY

An Anti-Democratic Philosopher

William Edward Hartpole Lecky, the philosopher who in the last quarter of the nineteenth century most weightily represented the spirit of caution and restraint in the presence of modern methods of change, was born near Dublin on March 26, 1838. Intended for the Church, he was educated first at Cheltenham and then at Trinity College, Dublin, where he graduated M.A. in 1863. But before that date he had twice appeared as an author, and had chosen literature as his profession. He was only twenty-two when his first book, "The Religious Tendencies of the Age," appeared, and next year, 1861, he published essays on four prominent Irishmen—Swift, Flood, Grattan, and O'Connell—under the title "The Leaders of Public Opinion in Ireland."

Lecky was one of the writers whose sympathy with, and faith in, popular causes weakened as he grew older. His early writings on his native country showed a temperate breadth that contrasted with the restriction of his views in later life. He made his mark as a historical and philosophical writer by his "History of the Rise and Influence of the Spirit of Rationalism," published in 1865. With the growth of mental and religious freedom, as it showed itself in the casting off of superstition, and an escape from dumb acquiescence in traditional forms of belief, and with the gradual predominance of secular life, Lecky displayed a quiet sympathy that perhaps was more effective than a bold partisanship would have been. The same spirit appears in his copious "History of England in the Eighteenth Century," a work that is not so much a record as a series of studies of scenes and events in their evolutionary sequence. The "History of European Morals, from Augustus to Charlemagne," published when Lecky was only thirty-one, threw light on a period that previously had been dark to the general reader of history.

These serious works won for Lecky the profound respect of thinkers of every school; and it was with misgivings that his admirers saw his entry into political life as member of Parliament for Dublin University in 1895. He held the seat till his death, on October 22, 1903, but did not add to his laurels by his work at Westminster, though the House paid considerable deference to him as a man of distinction in other fields. In 1902 Lecky was one of the original recipients of the Order of Merit. His last books were "Democracy and Liberty," published in 1896, and "The Map of Life"—practical essays on Conduct and Character—published in 1899.

In the first of these works his philosophy was brought to the touchstone of present-day events and problems, and upon it largely rests his final claim to be regarded as a political philosopher. In it he traces the influences of democracy in England, France, and the United States—in relation to taxation, landed and other properties; to forms of government and judicial functions; to religion, education, intoxicating drink; to marriage, labour questions, and Socialistic growths; and he finishes with a survey of women's questions, ending his book with a reluctant prophecy of the ultimate triumph of women's suffrage.

On all these subjects Lecky gives an impression of a singularly wide outlook, and is prolific in suggestions that demand grave individual thought, but he is fettered by a lack of generous faith in mankind and its destiny. Perhaps that was because his long practice of toleration in judgment had made bold opinions of his own almost an impossibility. But among armchair philosophers, who, from the library, distrust democratic developments, none has been more conspicuously desirous of fairness than he. As

yet the world only has fragments of a philosophy of politics. Whatever the value of the fragments contributed to the gathering stock by Mr. Lecky, the spirit of his inquiry will always remain an ensample.

GOTTFRIED WILHELM LEIBNITZ

An Encyclopædic Genius

Gottfried Wilhelm Leibnitz was born on July 1, 1646, at Leipsic, where his father held a Chair in the University. His first studies were directed to legal and practical matters, but he was endowed with mathematical genius, and soon invented a calculating machine, and discovered the differential and integral calculus. This

GOTTFRIED LEIBNITZ

gave rise to a celebrated controversy between Leibnitz and Newton, whose acquaintance he had made in London, as to priority in their mathematical discoveries.

In 1676 Leibnitz became librarian to the Duke of Brunswick at Hanover, and there he did very useful work in connection with such very various matters as the drainage of mines and the reconciliation of the Churches.

The most important of his philosophical works is his "Monadologie," which was published in 1714, and his "New Essays," which contain his celebrated criticism of Locke. The English thinker had combated the doctrine of "innate ideas"—as of God and duty—by declaring that "There is nothing in the mind which was not first in the senses." To this Leibnitz replied with the all-significant addendum: "Except the mind itself."

The celebrated doctrine of monads, which we owe to Leibnitz, has frequently recurred in the speculations of subsequent thinkers. These monads, according to Leibnitz, are the indivisible units of things, and they each have a psychical side—an individuality or "soul." But, further, there is a sort of hierarchy of monads, ranging from God Himself down to the smallest atoms. Every monad is true to the laws of its own nature, and acts accordingly. Yet it is at the same time in complete harmony with the rest. Here is the doctrine of the "pre-existent harmony" which the universe demonstrates; and since this harmony is contrived and maintained by God, we reach the conclusion that this is "the best of all possible worlds." Such is the Monadology of Leibnitz.

This remarkable man was a courtier by nature, and we can never be sure of the absolute independence of his thinking. He became a privy councillor and baron, and died at Hanover on November 14, 1716.

JOHN LOCKE

Philosopher, Educationist, Tolerationist

John Locke, the most influential European thinker of his day, and the most English of all philosophers, was born at Wrington, Somersetshire, on August 29, 1632, the son of a Puritan country lawyer, who was captain of a troop of horse on the Parliamentary side in the Civil War. This sterling father kept the boy "in much awe" when young, as was the custom of the times, but became his companion in later years. Locke was educated at Westminster School and Christ Church, Oxford, and in neither stage thought well of the type of education offered him, though he took such advantage of it that he became, successively, Greek lecturer at his college, lecturer in rhetoric, and senior censor of moral philosophy. Later, although he never entered the Church, he was awarded, by special dispensation, a senior studentship available only for men in Holy Orders. This studentship he held—to the honour of Oxford—for eighteen years, till expelled from it—to the disgrace of Oxford—by Royal command for political offences which were never formulated.

Locke's studies led him in the direction of medicine, and, though he was never granted the degree of doctor of medicine by his university—largely for political reasons—he practised medicine, was commonly spoken of as "Dr." Locke, and was accepted as one

of themselves by the best doctors of the day, particularly Sydenham, who saw in him a man "with few equals and no superiors."

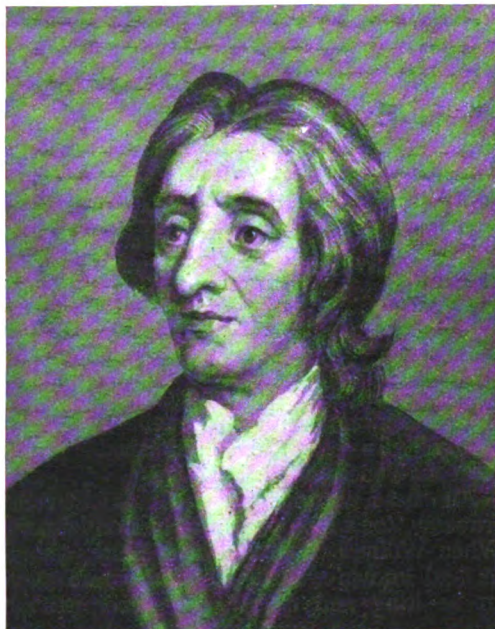
Then, at intervals, Locke filled various public offices, and might have had positions of the greatest influence if his health had allowed him to live anywhere and labour continuously. But he existed to the age of seventy-two inseparable from asthma, and on the verge of consumption. Yet Locke was not only a philosopher, scholar, and scientific investigator, but, as far as his health allowed, a successful man of affairs.

When he was thirty-three he was appointed secretary to an embassy to the Elector of Brandenburg, and greatly enjoyed life abroad, for he was a shrewd and humorous observer. On his return he was offered the secretaryship of the Spanish Embassy, but declined it on the score of health. In 1666 he met the Whig politician Lord Ashley, who later was Lord Shaftesbury, and they remained friends for life.

His "Essay Concerning Toleration" probably belongs to this time, and was suggested as a subject by Ashley. Locke contended that "all speculative opinions and religious worship have a clear right to universal toleration." Everyone may use "a perfect uncontrollable liberty, provided always that it be all done sincerely and out of conscience to God."

He acted as tutor to Ashley's only son, and, though a bachelor himself, was even entrusted with the duty of finding a wife for his pupil. This he did, most happily and successfully. At this time Locke became secretary and general manager to the "lords-proprietors" of the colony of Carolina. All the while, however busy he might be, his interest in scientific experiments continued, and in 1668 he was elected a Fellow of the Royal Society. It was out of his discussions with friends in this scientific circle that his "Essay Concerning Human Understanding" sprang, and, after nearly twenty years of elaboration, gave him a world-wide and enduring fame. In it he set himself to trace the ultimate source of the simplest ideas.

In 1672 Locke's friend Shaftesbury became Lord High Chancellor, and appointed him Secretary of Presentations, at a salary of £300 a year, and so the Chancellor's share of Church patronage passed through his hands. The next year, however, Shaftesbury lost the favour of Charles the fickle, and Locke went with him into retirement. Now, however, he was sufficiently well off to be able to nurse his health and live a life of reflection, as, his father being dead, he had inherited a small Somerset estate, and also had a pension of £100 a year from Shaftesbury, and the proceeds of his Oxford studentship.

Attempting to regain normal health, Locke now spent fourteen months in the South of France, chiefly at Montpellier, but he benefited but little by the change. Returning to Paris, he acted for two years as a tutor abroad of a son of Sir John Banks, and in the course of his travels visited Rome. Not till 1679 did he reach London, where his friend Shaftesbury, after a year's imprisonment in the Tower, was once more in office as President of the Council. Locke again

JOHN LOCKE

lived in Shaftesbury's house, and gave an eye to the education of his grandson, who in later years said he owed to him "the greatest obligation, the highest gratitude and duty." Locke, in fact, had in a singular degree the power of winning the admiration and affection of the young people over whose education he watched.

In 1681 Shaftesbury was again sent to the Tower, but on being brought to trial was acquitted by the grand jury. Next year, however, he thought it better to make his way to Holland; and there he died. Locke at this time was living at Oxford, and was under the closest surveillance. Spies watched him on every hand, but he was so discreet in his references to public affairs that he could not be caught. However, he

thought it advisable to withdraw from these offensive attentions, and went to Holland, where, in Amsterdam, Utrecht, and Rotterdam, with visits to other towns, he stayed more than five years. It was during this period, in 1684, that he was subserviently ejected, under order of the king, from Oxford, although the dean of his college declared that "there is not anyone in the college, however familiar with him, who has heard him speak a word either against or so much as concerning the Government." His name, however, was on a list of persons whose surrender was demanded from the Dutch Government, which took no steps to comply with such an outrage on liberty. Later—in 1686—Locke was assured that he could count on a pardon, but he replied that, "having been guilty of no crime, he had no occasion for a pardon."

It was this residence in Holland that changed Locke from a man who thought for his own satisfaction into one who wrote for the instruction of mankind. Hitherto he had published nothing of importance. Now, in his fifty-fourth year, in the safety of Holland, and under the stimulus of his Dutch friends—men of the rarest fidelity and affection—he gave the world his "Letter on Toleration," and within four years (1689-1693) his "Treatise on Civil Government," "Essay Concerning Human Understanding," and "Thoughts on Education." In 1695 he published "The Reasonableness of Christianity."

All these writings involved him in controversy, for which presently he had leisure. When William of Orange and Mary, whom he had known well in Holland, came over to be king and queen, he accompanied Mary, as she crossed later than her husband; and he was at once offered the ambassadorship to Brandenburg, which he declined, whereupon he was made a Commissioner of Appeals, and, in 1696, a Commissioner of the Board of Trade. In 1700 he retired from public service. The last fourteen years of his life were spent in great happiness with his friends Lord and Lady Masham, at High Laver, Epping, and there, on October 28, 1704, he died, "in perfect charity with all men, and in sincere communion with the whole Church of Christ, by whatever name Christ's followers call themselves." Lady Masham, who was with him when he died, said Time will "never produce a more eminent example of reason and religion living and dying."

Locke's work in philosophy, politics, education, and religion has all endured, and still forms a basis for study. He argued in the "Essay on the Human Understanding" that all our knowledge is derived from experience, and is not innate. The senses are the sources of most ideas, and the others come from what he calls the internal sense of reflection. The essay is an attempt to show that all ideas break up into these two simple forms. His philosophy was not a settlement—what philosophy is?—but it was a remarkable starting-point. As Professor Fowler says in his delightful monograph, "The office which Bacon assigns to himself with reference to knowledge generally might well have been claimed by Locke with reference to the science of the mind. Both of them did far more than merely play the part of a herald, but of both alike it was emphatically true that they 'rang the bell to call the wits together.'"

Locke's writings on religion and toleration were all in favour of the large-mindedness which has been slowly growing from his day to ours. His writings on education take a foremost place in the books of all nations dealing with the subject. He held that knowledge can only be truly acquired by the exercise of the reason, and that, till children can reason, their education should consist of the formation of habits. He saw education in three progressive aspects—physical, moral, and intellectual. The primary object was not instruction or the acquirement of information, but training in character. Education was, in short, a moral discipline—"that and that only is educative which moulds or modifies the soul or mind." He had regard rather to what a boy will *be* (as Mr. R. H. Quick points out) than what he will *do* or *know*. For if character is right, all the rest follows.

And he exemplified this view in his own character. A loyal friend, faithful to the truth that was in him, he lived the life he taught; and on whatever subject he wrote he put forth practical views that cannot be neglected, advancing and holding them in a spirit that remains a perpetual lesson in the ethics of controversy.

LUCRETIUS

The Finest Thinker who Used the Latin Tongue

Titus Carus Lucretius was born, probably, in 94 or 99 B.C., and is famous as the author of the unique poem "On the Nature of Things," in which he sought to popularise and express in poetic form ideas as to the origin and nature of the Universe derived from Democritus and Epicurus. He believed in the law of cause and effect, in the

natural order as untouched by the caprice of any fabled gods; and no one in any age has more powerfully attacked superstition aping religion than Lucretius in his great poem. He denied the immortality of the soul, and any bliss beyond the grave. The best good for man was therefore to be found in the renunciation of all religious beliefs, and in a calm acceptance of the laws of the universe. This is not a philosophy which might be expected to lend itself to poetic treatment, but the poem of Lucretius is, in fact, one of the glories of ancient literature, transcending for depth and beauty anything else written in the Latin tongue.

Tennyson's poem "Lucretius" gives a better idea of the Lucretian philosophy than can be obtained otherwise than by reading the poem in the original, or in one of the many excellent translations. "It is not the man who rejects the gods of the crowd, but the man who accepts them, that is godless," says Lucretius; and we may remember that saying before we too readily accept such a verdict as Newman's on this great thinker. We cannot here quote the many noble and touching and lovely and often-quoted lines and phrases which are to be found in Lucretius's poem, nor all the popular ones, such as "What is one man's meat is another man's poison." But we must quote the most beautiful and splendid line of all—that each of us is like a runner, who carries on the lamp of life until he falls, and then hands it to another to carry in his turn. Here Lucretius saw the parallel between certain races held in his time, and the great race run by the human race, with its individuals who come and pass away, but hand on to ages yet unborn the undying lamp of life.

In this great task Lucretius—poet, thinker, prophet, hater of lies—did his splendid share. He is said to have lost his reason before his death, which was stated —perhaps by his enemies—to have been due to his own hand, in his forty-fourth year.

WILLIAM McDOUGALL
A Great Student of Human Conduct

William McDougall was born in 1871, and educated at Owens College, Manchester, St. Thomas's Hospital, in London, and Cambridge. Having taken a medical degree he devoted himself to research in the borderland between physiology and psychology. He also travelled, and has turned to good purpose his observations upon the pagan tribes of Borneo, whom he studied carefully at first-hand. In 1898 Dr. McDougall was elected a Fellow of St. John's College, Cambridge. A few years years later he carried the Cambridge methods and traditions in psychology as a science to the sister university, and became Wilde Reader in Mental Philosophy at Oxford.

It is to be hoped and expected that, in time, Dr. McDougall will be able to make a new tradition for psychology in Oxford, for he recognises that this is a science to be studied like other sciences, and that the time for evolving the facts and laws of the mind out of the philosopher's own head has passed. Already he has prosecuted several experiments, upon himself and others, which must be very astonishing to those Oxford pundits who look upon mental philosophy as a species of metaphysics.

Thus Dr. McDougall has published results of the experimental taking of alcohol, with measurements of its influence upon mental processes. In this research he established a new standard of precision, by so concealing the alchohol that he, or the subject of the experiment, did not know when or whether it had been taken. He has also made a special study of fatigue, a state which may yet be controllable on the principle of antitoxin medication.

The general body of students of psychology were first made acquainted with Dr. McDougall in his "Temple Primer," published in 1905, under the title "Physiological Psychology." Certainly nothing had ever been published, for the sum of one shilling, which offered so much to the psychologist. This little book is a triumph of lucid and authoritative statement.

Already in this book we see the advantage which the writer and his readers must gain from his preparation in biology. Unlike the great majority of his predecessors, he does not try to build a psychology in mid-air. He has climbed to his knowledge upon a foundation of the lower sciences. In this respect Dr. McDougall resembles Professor William James, whose natural successor he is evidently destined to be. His outlook is primarily, but not wholly, physiological; and, as he is born in the evolutionary era, he naturally "thinks in evolution."

This is made very clear and fruitful in his most original and important book, which is called "Social Psychology," and was published in 1908. The volume has made a profound impression wherever psychology is read, and no modern student can afford to be without it. The author does not deal, as the title might suggest, with the "mob-mind," or the collective behaviour of men.

He takes the individual, for the time being leaves out of account the merely logical processes with which psychology has so long been obsessed, and asks how and why this being *feels* and *acts*. The answers to these questions will teach us how to understand human life as we see it in society. Man is naturally a social animal, and his societies are the product of his nature. We must therefore examine his nature, looking, above all, not at mere logic or speech or profession, but at conduct and its springs.

Now, though animals do not speak, and though their logical processes are few, they exhibit conduct, as we do; and their behaviour varies widely in different species and individuals. The problem is therefore one to be solved not by looking at any one species, such as man, but by adopting the standpoint of comparative psychology.

At this point, Dr. McDougall builds upon and greatly extends the work of William James. The American psychologist had seen how difficult it is to distinguish exactly between what we call emotions and what we call instincts, and he had always refuted the general theory of the older psychologists, and of the public, that animals have instincts, whereas man has intelligence. We are as rich in instincts as any other creatures, he said.

Dr. McDougall has completed the argument, and has placed our understanding of human instinct and emotion upon a new plane. Instinctive act and emotional state, he teaches us, are the external and internal aspects of the one thing. When animals act instinctively, they feel corresponding emotions; when we act and feel, our action is really instinctive, and emotion is its subjective side. There is no real distinction at all between the behaviour of, say, Darwin's baboon, or a human hero who saves a child from the wolves. It therefore should be possible to analyse human emotions and instincts, pairing them duly—as, for instance, fear and flight, tenderness and the manifestations of parental instinct, anger and pugnacity, and so forth. It becomes possible, also, to show how certain emotions, such as awe, are compounds made by a synthesis of certain "primary emotions," such as fear and wonder. It is not too much to say that the publication of this small volume has opened a new chapter in psychology, and has placed its author in the very forefront of living students of the subject.

Thanks principally, no doubt, to his physiological researches—for the Royal Society does not recognise purely mental research and elucidation, however valuable—Dr. McDougall was made a Fellow of that body in 1912. He has lectured on various occasions in London for the Sociological Society, of which he is a distinguished member, his last lecture, on "The Will of the People," being attended by a crowd of students come to hear a new leader in the great science of the mind.

Most significant of all, from the standpoint of philosophy, is Dr. McDougall's largest and most recent book, "Body and Mind," published in 1911. The significant sub-title of this volume is "A History and a Defence of Animism," and its essential thesis is that the "mechanical dogma" must be abandoned, and the soul restored to science. "I am aware," says the author, "that to many minds it must appear nothing short of a scandal that anyone occupying a position in an academy of learning, other than a Roman Catholic seminary, should in this twentieth century defend the old-world notion of the soul of man. For it is matter of common knowledge that 'Science' has given its verdict against the soul. . . . But I am aware also that not one in a hundred of those scientists and philosophers who confidently and even scornfully reject the notion has made any impartial and thorough attempt to think out the psycho-physical problem in the light of all the relevant data now available, and of the history of previous thought on the question. And I am young enough to believe that there is amongst us a considerable number of persons who prefer the dispassionate pursuit of truth to the interests of any system."

On this high prophetic note we may leave Dr. McDougall, who is now the leading advocate in our own country of the doctrine which he calls "animism," and which Driesch, in Germany, and Bergson, in France, are now advocating with such success, each along his own original and independent but convergent line. Our century has no better omen.

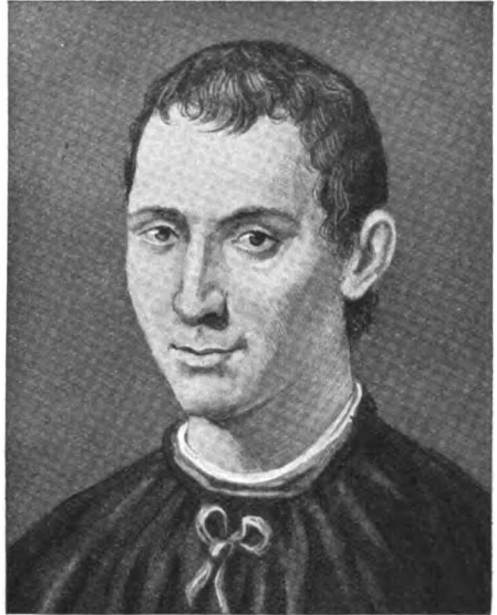
NICCOLO MACHIAVELLI
The Founder of Political Science

Niccolò Machiavelli, the founder of political science, was born at Florence on May 3, 1469. He belonged to a noble family which had exchanged the dignities of feudal lordship for the privileges of citizenship under the Republic. Many members of the family had sat on the Executive Council. Niccolò's father was a lawyer with a moderate income. Little is known of the

son's early years and education. Like his eminent contemporary Ariosto, he was deeply versed in the literature of his own nation, and to this may be attributed the ease, grace, and manliness of his literary style. He was also a profound student of Latin history, particularly in its bearing on Roman statecraft and the art of war.

In 1494 a French invasion under Charles VIII. menaced Florence. Pietro Medici, the ruler, accepted humiliating terms, and was promptly expelled from the city by the enraged Florentines. The Republic was restored, and Machiavelli now first entered public life under its auspices. In 1498 he was elevated to the rank of Chief-Secretary to the Government, a post which he held until 1512. His time was fully occupied with home and foreign correspondence and with military organisation, but his rare gifts especially fitted him for delicate negotiations, and he was therefore sent at different times on no fewer than twenty-three embassies. Contact with the subtle minds of his own and other races, and diligent observation of different social and constitutional usages, had much to do in shaping the political principles that were later developed in his literary works.

In 1502 he was sent on a mission to tne camp of Cesare Borgia, known as Duke Valentine. Machiavelli had thus the opportunity of watching the devious intrigues of that cunning and unscrupulous general. With the implacable Borgia, treachery and murder were commonplace and legitimate weapons for the removal of obstacles. But such cold-blooded disregard of every moral consideration, when a desirable end was in view, was readily condoned by an Italian of the fifteenth century; and there is little doubt that, while openly condemning Borgia's behaviour, Machiavelli secretly admired the dexterous union of audacity and fraud employed to accomplish the duke's designs. Machiavelli's attitude is only rendered intelligible by taking into account the spirit of the age. Italy was the slave of despotisms, and private morality was entirely subordinated to the exigencies of State policy or of personal ambition.

Machiavelli's despatches from France and Germany reveal astonishing insight into the nature and conditions of national life. He also studied the theory of war with the closest application. Macaulay, in one of his most brilliant essays, points out that, "though his opinions had not escaped the contagion of that political immorality which was common among his countrymen, his natural disposition seems to have been rather stern and impetuous than pliant and artful." The sincerity of his patriotism is, at any rate, beyond all dispute. Florence suffered, unhappily, from the necessary evil of employing mercenary troops. Machiavelli, who had read Livy, and approved the Roman model, was eager to replace this corruptible soldiery with a citizen army. He was supported by Soderini, the head of the Republic, and successfully raised a levy of foot-soldiers from the country districts around Florence. His enthusiasm and fidelity were not rewarded as they deserved, but it was his weakness to leave out the qualification of moral conduct when choosing the commander of his new militia. In the hour of need the army proved inefficient, and his dream of securing the permanent honour and independence of his beloved Republic was unrealised. The Medici returned in 1512, and Machiavelli did not find favour under the new régime. He lost his offices, and was charged in the following year with conspiracy. He was imprisoned and tortured, but was set free on the election of Giovanni de Medici to the Papacy, in 1513. Exile followed, and for several years he remained out of public life, living in poverty at his villa in San Casciana. Here he wrote his world-famous book "Il Principe" ("The Prince").

NICCOLO MACHIAVELLI

The book opens by enumerating the various kinds of principalities, and by

stating rules and principles, some benevolent, some drastic, for each form of government. For example, where usurpation has been effected, he advises that such penal measures as are deemed necessary should be applied once and for all, and with such severity as not to require repetition. A prince may then afford to be mild and beneficent, "but benefits should be distilled by drops, that the relish may be the greater." Again, after affirming that it was always the opinion of wise men that the stability of a State depends on its army being composed of the prince's own subjects, citizens, or servants, he proceeds to give some excellent counsel on the training of a field officer. Bodily exercise, such as hunting, exposure to hardships, hunger and thirst, minute geographical knowledge of the coasts, mountain chains, rivers, and fens—these are all necessary. No man is suitable for a commander till he is a master of detail.

In the notorious eighteenth chapter he discusses whether a prince is absolutely bound to keep his promises. Defending the negative view, he says a prince must be partly lion, partly fox; he must possess the skill to detect snares. A prudent prince cannot, or ought not, to keep his word when the keeping of it involves him in difficulties. In other words, private ethics must yield to political expediency. Expediency excuses dissimulation. Expediency necessitates, for the preservation of the State, that a ruler must often do things that are inhuman, uncharitable, and dishonourable.

This peculiar immorality, as Macaulay has shown, belongs "rather to the age than to the man, was a partial taint, and by no means implied general depravity." Indeed, Machiavelli did not undervalue private virtue, but regarded it as the foundation of healthy national life; and after eliminating the perverted portions of his teaching, it may be said that Machiavelli has left to posterity a great legacy of marvellous literature and scientific principles.

Other works include "The Marriage of Belphegor," a comedy little inferior to some of Molière's; and a "History of Florence."

Machiavelli died on June 22, 1527, sadly lamenting that he was not permitted to join in the latest popular movement for the liberty of Florence. His genius has gradually come to be understood, notwithstanding the sinister significance attached to his name; and though much that he wrote is cynically immoral, much else is seriously acknowledged to have laid the foundations of political science.

THOMAS ROBERT MALTHUS
A Student of the Law of Population

Thomas Robert Malthus, the first thinker to treat systematically the principles of population, was born at the Rookery, near Dorking, in Surrey, February 17, 1766. He was very carefully educated by private tutors, and sent to Cambridge University in 1784. He was ninth Wrangler in 1788, and became Fellow of his college (Jesus) in 1797. The same year he was ordained, and appointed to a parish in his native county, still, however, retaining his Fellowship. The first edition of his great work "An Essay on the Principles of Population as it Affects the Future Improvement of Society" was published anonymously in 1798. The doctrines of the book were eagerly read, and widely canvassed and challenged. Stimulated to further study of the subject, Malthus pursued his investigations in Norway, France, and Switzerland; and in 1803 a greatly enlarged edition appeared, containing such important modifications that the author himself described it as "a new work." He married happily in 1804, and soon afterwards became Professor of Modern History and Political Economy in the East India Company's College at Haileybury, a position he held until his death.

Malthus was a man of upright and amiable character, and so calmly conscious of the high moral purpose he had in view that he could afford to ignore the abuse and misrepresentation of his assailants. The "Essay" was suggested by a paper in William Godwin's "Enquirer." Godwin, like his master, Rousseau, was dreaming of the perfectibility of human society. Every village was to be an elysian community. Wealth and labour would be equally shared by all; there would be no sacred rights in property, and no marriage bonds to disturb the even flow of universal enjoyment and ease. Malthus, however, was not infected with these illusory ideas, and the arguments he opposed to them are always ingenious, even when they are inconclusive.

Restricting himself to one great cause affecting the whole fabric of society—a cause which had hitherto attracted little notice—he points out the inevitable tendency of all organic life to increase more rapidly than the sustenance necessary to support it. In the case of plants and animals, want of room and scarcity of food are ruthless checks to propagation, but with man the problem is more intricate, owing to the operation of human reason and

the complexities of civilised society. With man, too, the ultimate and unfailing check upon population is the want of food. The immediate checks operate through human motives, through diseases arising from absence of nutrition, and through causes having no relation to necessity, but which undermine or utterly destroy the bodily frame.

These checks are either preventive or positive. In the former class are moral restraint and vice. In the positive class are included, amongst others, "all unwholesome occupations, severe labour, and exposure to the seasons, extreme poverty, bad nursing of children, large towns, excesses of all kinds, the whole train of common diseases, wars, and famine."

Discussing the comparison between the natural increase of population and the collateral increase in the food supply, Malthus considered it safe to assume that population, if unchecked, would go on doubling every twenty-five years—that is to say, in a geometrical ratio—but that the produce of the soil could only increase, at the most, by equal increments in each successive period. Hence he deduces the following laws—that population would soon outstrip the means of subsistence if it were not kept down by misery, vice, or moral restraint; that when conscientious restraint is non-existent, or only slightly prevails, population will increase until the poorest classes find it very difficult to maintain life. Examining the history of various countries and races, Malthus gives exhaustive details of the checks, such as infanticide, epidemics, brutal practices, and pestilence, that have effectually reduced or decimated the populations of savage tribes and of modern pastoral nations, and proves that the ever-growing possibility of excess in population has influenced the development of society in all its stages.

Malthus held the opinion that institutions which sought to impose social equality could not bring about a stricter restraint upon population. The operation of prudential considerations would cease if private ownership gave place to equality and community of goods. This doctrine evoked the bitterest invective of theoretic communists like Louis Blanc, to whom the notion of moral restraint was objectionable. Yet in the practical communistic societies of the United States, and contrary to the views of Malthus, celibacy and discouragement of marriage are cardinal features. In one of these societies, of German origin, no man is allowed to marry under twenty-four years of age. But it is more than doubtful if such autocratic control as that exercised by the chief of a small community could be applied to government on a much larger scale. The formula of Malthus, which states that "population increases in a geometrical ratio, food in an arithmetical ratio," has not been accepted by later economists, and has, in fact, been proved erroneous—indeed, it is now argued that food tends to increase faster than population, and the argument is constantly strengthened by scientific discoveries.

The theories of population which Malthus amplified were not entirely new. Plato and Aristotle had written on the subject. Hume, Benjamin Franklin, and others had expressed similar views to those in the "Essay." Darwin acknowledges his indebtedness by saying that "he saw on reading Malthus 'On Population' that natural selection was the inevitable result of the rapid increase of all organic beings." If the conclusions of Malthus were chargeable with exaggeration, it must be added that he created a totally new feeling on the subject. Emigration, the opening out of vast and fertile tracts of untilled land, and the increase in the productivity of all land by new scientific processes will indefinitely postpone, and may perhaps completely obviate, the difficulties foreshadowed by Malthus.

It ought to be clearly understood that no word of Malthus is responsible for the immoral theories sometimes associated with his name. He gave his sanction only to the doctrine of moral self-restraint; and his one precept, "Do not marry till you have a fair prospect of supporting a family," is sane, wise, and obviously emphasises the responsibilities of parentage. He died near Bath, December 23, 1834.

JOSEPH MAZZINI
Politics as a Religion

Joseph Mazzini, the Italian patriot who insisted that a true democracy must accept its politics as a religion, was born in Genoa on June 22, 1805. He was educated at the University of Genoa, but while still a student was constantly revolving in his mind how he could help to free and unite his country—an aim that was strengthened by democratic parents. Beginning life as an advocate with literary habits, he threw up a promising career to adopt, deliberately, the rôle of a political agitator, and at the age of twenty-four joined the secret society of the Carbonari.

In less than a year he was trapped and imprisoned in the little Riviera town of Savona, but on being tried he was acquitted. Leaving Italy for Switzerland, and, later, for France, he there planned an organisation for attempting to secure the freedom and unity of Italy, with the hope that Italy would then become a centre from which the political regeneration of all Europe might be effected. This Young Italy Association, which was operated first from Marseilles, then from Geneva, and finally from London, attempted two abortive risings in Italy, neither of which had any chance of success; and, after them, Mazzini was expelled, first from France and then from Switzerland. The arch-plotter was condemned to death by his country while he was yet free. Several of his fellow-conspirators were executed, and others imprisoned for long terms of years.

Mazzini arrived in England in January, 1837, and remained there in poverty, but always pursuing his patriotic aims, for eleven years. It was during this period that the British Government opened his letters in collusion with his Continental enemies; and Thomas Carlyle, denouncing them for acting the part of spy and informer, declared, in the "Times":

"I can with great freedom testify to all men that he, if ever I have seen one such, is a man of genius and virtue, a man of sterling veracity, humanity, and nobleness of mind, one of those rare men, numerable, unfortunately, but as units in this world, who are worthy to be called martyr souls." The outcome was that Sir James Graham, the Home Secretary of the day, apologised in the House of Commons for unjust opinions he had expressed with regard to the exile.

When the Lombard insurrection of 1848 broke out, Mazzini joined it at Milan, and, after its failure, went to Leghorn, where he was elected deputy to the Republic established in Rome after the Pope had fled. There, as one of a triumvirate—Saffi and Armellini being the others—he adopted the motto "God and the People," a phrase that expressed the essence of his life's work. In three months the Republic fell before the bayonets of the French, who reinstated the Pope; and Mazzini returned to London, physically a broken man after his efforts in defence of the city.

A born conspirator, he planned other risings; and when, through the united action of Cavour, Victor Emmanuel, and the third Napoleon, Italy was united under the House of Savoy, though in a truncated state, Mazzini would not agree, and broke with his friend and colleague Garibaldi. His Republican principles were outraged, and he regarded the compromise-unity of his native land as a weak deflection from the line of duty. For a third time he was sentenced to death, and as a protest was elected four times in succession, in his absence from Italy, member for Messina.

After the withdrawal of the French from Rome, and the establishment of the capital in the Eternal City, Mazzini, whose health was shattered, returned to Italy, but died at Pisa on March 10, 1872. He lies in the great Campo Santo, above his native city of Genoa, after a national funeral attended by eighty thousand people; and Italy, the land of monumental statuary, commemorates him as one of her saviours, with Garibaldi, Cavour, and Victor Emmanuel.

The character and political philosophy of Mazzini can only be appreciated when his central belief is realised as it is set forth in his works "On the Duties of Man" and "Thoughts Upon Democracy in Europe." He held, and argued with Italian fervour, that the French Revolution was being wrongly regarded. It was treated by liberated peoples as the beginning of an era in which human rights were established, to the end that individual happiness might be attained and preserved. That, contended Mazzini, is all wrong. The French Revolution simply ended a period of tyranny and repression, and should be the starting point for a new constructive policy which ought to arise spontaneously from the mass of the people, and be held by them as a religion. The watchword of this new policy should not be *Rights* but *Duty*. The Divine Will is that men should live together collectively, in love and mutual happiness, working for a common object, the general good, with which all individual interests are bound up; and, with minds fixed on that strife and sacrifice for all, politics must become a religion. No true society can be founded on individual gain. "It was not to attain the ignoble and immoral 'everyone for himself' that so many holy martyrs of thought have shed, from century to century, the tears of the soul." He held that the true form of government was a religious commonwealth, based on duty, and the willing self-sacrifice which only gains by giving. A lofty ideal, whose need is seen more and more with the passage of each decade. In the presence of such purity of motive, diplomacy looked mean, and the giving of governments to people from above futile. Only as the mass of the people

cherished a lofty ideal of communal life, with mutual happiness as its aim and a religious fervour as its driving force, would true progress be made, according to Mazzini. And this he believed to be the Will of God. Hence his motto, " God and the People."

It has been said against him that he ruthlessly sacrificed his friends for the cause he believed in. So he did. He equally sacrificed himself. It was of the essence of his faith that men should sacrifice themselves for the ultimate good of all. In this respect he was, as Carlyle said of him, " merciful and fierce." Mazzini had his own noble philosophy, and he pursued it consistently, even when he saw his country falling away from him for a temporary gain. He believed in the " new birth " of mankind into collective unselfishness, and he died in that faith, disappointed, no doubt, but still not disillusionised.

JOHN STUART MILL

"The Saint of Rationalism"

John Stuart Mill, one of the most acute and sincere thinkers of the nineteenth century, the consummator of the doctrine of utilitarianism, and, as Mr. Gladstone said, " the saint of Rationalism," was the son of a man of great ability and profound public spirit, James Mill, of the East India Company. John Stuart Mill was born on May 20, 1806. About his youth we know everything, for in his later life he wrote an entirely frank Autobiography. James Mill had ideas of the upbringing of a child that were utterly at variance with modern educational methods. He undertook the education of the boy, and it became for the time being a ruling passion, an intellectual debauch. Had not the natural disposition of the lad been one of extraordinary sweetness and obedience, he would have been ruined in every way. John Stuart never remembered when he could not read Greek. Certainly he could read it at the age of three, and when the modern child is leaving the infant school he was an all-round classical scholar. Even his hours of exercise were not free, for his father walked with him and delivered to him lectures on political economy. James Mill belonged to the school of bloodless humanitarianism identified with the supremely intellectual and respectable, but hateful, name of Jeremy Bentham, that has utility as its watchword, but was blind half way round the horizon. By the time young Mill had reached his seventeenth year he was simply gorged with education, though it must be admitted he never showed any signs of being satiated. His father now got him a post in the East India Company's office, and there he served faithfully for thirty-five years, rising to be the head of his department, at a salary of £2000 a year. When, after the Mutiny, the Government took over the company's responsibilities, Mill was pensioned off, with a retiring allowance of £1500 a year. He lived fifteen years longer, dying at Avignon—where he is buried—within a fortnight of the age of sixty-seven (May 8, 1873). During the period of 1865-68 he was Radical member of Parliament for Westminster.

The inner story of Mill's life, as read through his Autobiography, and through his works, consists of his gradual broadening and partial emancipation from the hard and dogmatic intellectuality of the school in which he had been brought up. Slowly he emerged into a knowledge of life that he ought to have had as a young man. He found an escape from the dry husks of philosophy through a love of Nature and a love of poetry, and eventually he married a widow who had long been his friend, and whom he idealised till their acquaintances did not know her when they saw her through his eyes. But whether he was building up his phenomenal knowledge by the dry labour of his rigid father, or expanding under the sunshine of life when human nature began to count, John Stuart Mill was a man of sweetest character, noblest instincts, keenest mind. Towards a whole generation of thoughtful Englishmen he stood in a relation of " intellectual fatherhood," to use a phrase of his most distinguished and consistent disciple, John Morley, who also has borne unstinted testimony to the richness of his culture, the full maturity of his wisdom, his passion for truth and justice, his " difficult tradition of patient and accurate thinking in union with unselfish and magnanimous living."

At the end of his extraordinarily unhealthy education Mill was left very much at sea. The dryasdust philosophy of Bentham, with its lifeless "greatest good for the greatest number," did not satisfy him, nor the promise of happiness to those who make happiness their aim. Indeed, he came to the conclusion that that was the way how not to do it—that to be happy we must have an object in life, but it must not be happiness ; and then happiness will come as a by-product. His object was to seek truth, wherever it was within reach of human thought and experience as laid down by Locke. Outside the operations of

human reasoning and the experiments of the senses, Mill would not go. He did not deny anything, and he would have liked to indulge in belief beyond his reasoning, but he would not ; it was out of bounds.

But what an immense amount there was within bounds ! There was the whole realm of Logic, and that he traversed in his "System of Logic"—his first book, published in 1843, after he had been contributing to periodical literature since early boyhood. There was Philosophy, and he wrote an "Examination of Sir William Hamilton's views." There was the realm of social-economics, and the theory of Bentham and his father, which he had himself renamed

JOHN STUART MILL

"Utilitarianism," but which he outgrew in its crude early forms, and expanded into a new reading of his own, that fluttered the older men of the faith sadly. There was the whole question of representative government, which men had begun to regard as settled, but which suggested to Mill that it might bring a tyranny of the majority scarcely less odious and unsound than a tyranny by a minority, and this led on to the writing of his great book on "Liberty." Then there was a question which halved the human race, and has become acute since Mill's day—the public relations of men and women ; and John Stuart Mill was the first man in the foremost rank of philosophers and thinkers who declared decisively against what he called "the subjection of woman." Lastly, there was the wide realm of commercial and industrial economics, and this fine, impartial thinker undertook to survey it in his "Principles of Political Economy"—a book which has been the pivot whereon discussion of the subject has mainly turned for sixty-five years.

It may be said that the main currents of the world's thought have left to some extent the channels through which Mill once directed them. Dependence on what the senses teach us by a narrow reading of their activities no longer satisfies us, since mind has re-emerged as an entity on its own account. The intense belief in individuality as exemplified in Mill is left in the cold in an age of Socialistic endeavour. The rigid action of economic "laws" is felt to be less inevitable in the case of man than was recognised before the age of invention subverted Nature and won entirely new means of subsistence. In all these respects there has been a withdrawal from the positions taken up by Mill. But his work will ever remain a landmark in many practical departments of human thought, and his character and public spirit objects of unaffected admiration.

JOHN MILTON
The Immortal Defender of Liberty

John Milton, the great poet, takes his place among the world-thinkers for two reasons apart from his poetry. Besides writing on the controversial, religious, and political questions of his day, and on questions that made a personal appeal to him—such as divorce—he published an interesting letter on education that gives a curious view of learning as it struck the scholarly men who followed close on the Renaissance ; and, above all, he wrote the most eloquent defence of liberty of thought and liberty in publication that exists in any tongue, ancient or modern.

Milton was born in Bread Street, off Cheapside, on December 9, 1608. His father was a scrivener with a sufficiency of means, and, though a strong Puritan, a lover of music and learning. In each of these respects his son resembled him. Educated first at Dean Colet's foundation, St. Paul's School, he entered Christ's College, Cambridge, in 1625 ; and though his experiences at the university were not all pleasant, he was long associated with it, and ranks as a great Cambridge man. Indeed, long after he had taken his M.A. degree, in

1632, he lived near the university, because of the learned companionship it afforded.

He settled down in the country at Horton with the deliberate intention of writing great poetry, and his writings in these early days will live while the English language lasts. They include the "Hymn to the Nativity," "L'Allegro," "Il Pensieroso," "Comus," and "Lycidas"—the finest English writing that is strictly classical. In 1638 and 1639 Milton was travelling, chiefly in Italy, where he met the greatest Italians of his age, and was already received as a poet who had secured fame.

Returning home, he undertook the education of his sister's children and others. Then, when the Civil War came, he turned to pamphleteering and public life, and held the office of Foreign Secretary to the Commonwealth from 1649 onwards. Throughout the troublous years of his middle life a few sonnets were the only products of his poetic genius, and in prose certain controversial writings which add nothing to his reputation, and the "Tractate on Education" and "Areopagitica"—commented on later. After the Restoration, when he was in some personal danger, Milton reverted to the ambition of his youth, and wrote "Paradise Lost," published in 1667; "Paradise Regained," 1671, and the magnificent and pathetic "Samson Agonistes." He died on November 8, 1674.

Milton was thrice married, first unhappily; then, after he became blind. in 1652, happily, but his wife did not live long. Lastly, he married a homely wife, who was a comfort to him when the daughters of his first wife proved churlish and unmanageable. His worldly circumstances became comparatively straitened in his later years, but he was never poor. His books were not a source of profit, though he had a most substantial contemporary literary fame. He and his wife received £18 for "Paradise Lost," and 1300 copies were almost immediately sold.

The "Tractate on Education" was written in the form of a letter to one Samuel Hartlib, a public-minded Anglo-Pole. It is remarkable for three features. First, like Ascham, Milton, in teaching languages, would get swiftly to the literature of the language, so that the student might secure the reward of enjoyment instead of being wearily cumbered by grammatical formulas. In the next place he realised that education should be all-round, and touch practical life as well as books. He would have his students physically trained, and, besides, practised in such sciences as agriculture, so that the productivity of the soil might be increased. Taken separately, nearly every item of Milton's educational scheme—which is very comprehensive—is excellent, judged from the modern standpoint. But the whole of it, as a demand made on the average student, is appalling in magnitude; and if he tried as a schoolmaster to impose it on his sister's children and other pupils we can accept the truth of the legend that the cries which accompanied their chastisement reached the ears of the scandalised neighbours. Milton himself was a prodigy of learning, and apparently did not realise the difference between the exceptional and the average intellect.

It is in the "Areopagitica," a letter, or supposed speech, to the Parliament of England—Lords and Commons—in favour of the liberty of unlicensed printing, that Milton takes rank with the great thinkers, and indeed embodies his thought in such lofty and moving language that it becomes great literature—perhaps the most splendid example of elaborate English prose.

Milton imagines the great Council of the Land assembled on some national Mars Hill —as in Athens—while he addresses them with a dignity worthy of a supreme occasion. And, indeed, the subject had an elemental greatness. All human progress depends on liberty of thought and its free exchange. But the Stuarts, through the Star Chamber, had insisted on a rigid control of the Press. Printers, booksellers, authors, and importers of thought from other countries were strictly controlled. Besides the King's printers and the Universities there could only be twenty printers in the land, and they were registered and checked. Not more than four typefounders were permitted.

The writings of all authors had to be passed by official judges, the narrowness of whose minds may be gathered from the fact that more than twenty years after the publication of the "Areopagitica" these hobbled minds "held up" "Paradise Lost" for a while, because Milton said that the coming of great solar eclipses "with fear of change perplexes monarchs."

This hidebound restriction of thought wrung the very soul of men like Milton, who realised that mental liberty is the most elementary human right. And yet the Commonwealth Parliament, on which he, and the likes of him, had reposed such hopes, actually issued an Ordinance in the same spirit as had been shown by the rejected Stuarts. It was in protest, grave

and fierce, against this Ordinance that Milton issued his memorable "Areopagitica."

He claimed the right to address Parliament in the public interests, as thoughtful men had done in ancient times. He did not deny that it was well "to have a vigilant eye on how books demean themselves, but to kill a good book—as well kill a man!" "A good book is the precious life-blood of a master-spirit embalmed and treasured up on purpose to a life beyond life." "Revolutions do not oft recover the loss of a rejected truth, for the want of which whole nations fare the worse."

In ancient times, books, said Milton, were not censored. How came the censorship to be established? The reply is, by the Inquisition. Was the Protestant Parliament proud of following that example? The Scriptural injunction was to "Prove all things, and hold fast that which is good." How could that be done with books if freedom were disallowed? If books are to be regulated, why not all amusements, music, conversation? Besides, who are these licensers to be? How can their cursory eyes judge the writing to which a man has given his life?

That is the line of Milton's argument; and then he rises to a purer height, and examines the very nature of Truth—man's "richest merchandise"—and England as the land of its defence. "Though all the winds of doctrine were let loose to play upon the earth, and Truth be in the field, we do injuriously, by licensing and prohibiting, to misdoubt her strength. Let her and Falsehood grapple; who ever knew Truth put to the worse in a free and open encounter? She needs no policies, no stratagems, no licensings to make her victorious, those are the shifts and the defences that error uses against her power—give her but room, and do not bind her when she sleeps."

Thought, sentiment, and a profound philosophy have never found more cogent and thrilling expression than in this immortal prose work by a great poet.

MONTESQUIEU

The First Evolutionary Historian

Charles de Secondat, Baron Montesquieu, the first thinker to treat history from a really philosophical standpoint, and an eminent writer on political science, was born at the château of La Brède, near Bordeaux, January 18, 1689. His uncle, Jean Baptiste de Secondat, was President of the Provincial Parliament of Guienne; and this important office, being hereditary, descended in due course to Charles, who in his youth was known as Monsieur de la Brède. Charles received an excellent education, and on leaving school made a diligent study of the law. At the age of twenty-four he became a councillor of the Parliament, and two years later, on the death of his uncle, he succeeded to the presidency, as well as to the family title of Montesquieu.

He was now wealthy and influential, and fond of good society. But he did not let pleasure interfere with his duties as a public-spirited magistrate, and he filled up his leisure in preparing papers on politics and natural science for the Bordeaux Academy. He was at the same time occupied with a more ambitious task, and in 1721 appeared, anonymously, the "Lettres Persanes," his earliest conspicuous literary success. The letters are supposed to be written by two Persian visitors to Paris, and in this fictitious correspondence Montesquieu wittily chastises the innumerable follies and corruptions of his age.

It was an era, in France, of shameless vice and amusement, and it is hardly surprising that Montesquieu should occasionally overstep the bounds of delicacy in a work of this kind, but the author mingles with his raillery much serious and searching criticism of king and Court; of the ignorant contempt for science; of the persecution inflicted on genius and intellect; of the status and education of women; and of the bickerings and insincerities of theologians. It was the first stirring of the miry pools in high places. Its pages were mirth-provoking, but they were also thought-inspiring. The book was popular enough to rouse the jealousy of Voltaire. The gay and dissolute Ministers of Louis XV. unquestionably laughed over its pleasantries, but its playful satire exposed the depravity of Church and State. For some reason or other no further editions were issued for nearly nine years.

Hungering for the amenities of Parisian society, Montesquieu sold the life tenure of his office, and in 1726 went to live in the capital. He was made a member of the Académie Française, and in 1728 started on a prolonged tour, with the object of studying the peoples and Constitutions of various European countries. He visited Austria, Hungary, and Italy, and in Venice became intimate with Lord Chesterfield. Then by way of the Rhine he travelled on to England, where he stayed for nearly two

years. Montesquieu shared the partiality which Voltaire always felt for England. Government which respected personal liberty, and was not unmindful of the public interest, won his profound admiration. He listened to the debates in the House of Commons, read Locke's political works, and was permanently affected with Anglomania. His best writings were strongly flavoured with English ideas; and on his return to his estate at La Brède he went so far as to lead the life and exercise the benevolent despotism of a typical English squire.

After settling down in his own country, Montesquieu devoted himself largely to literature, and in 1734 was published, at Amsterdam, his historical masterpiece, "Considérations sur les Causes de la Grandeur et de la Décadence des Romains." It is a strikingly able book, condensed and weighty and amazingly clear, if somewhat grandiloquent in style. It traces with scientific skill the causes which influenced the expansion and political development of the Roman Empire, and covers the period from its legendary beginning to the Fall of Constantinople. It is an exceedingly valuable contribution to the philosophy of history. Twelve years elapsed before Montesquieu published (1748) what has been regarded as the greatest book in the French literature of the eighteenth century, "L'Esprit des Lois." The abbreviated title does not sufficiently explain its scope. Its object is to show the relation which laws should bear to the constitution of each government, the manners, climate, religion, commerce, etc. It consists of thirty-one books dealing with law in general, taxation, manners and customs and their dependence on climatic conditions, economic questions, religion, and feudal law. The work suffered the distinction of being placed on the Index Prohibitorum; and the the reactionary theologians of the Sorbonne threatened it with a formal censure, notwithstanding the marked moderation with which the author discussed the subject of religion.

As Montesquieu had anticipated Gibbon in Roman history, so also he anticipated Buckle and others in his views on the influence of climate. An interesting section of the work is that which expounds the constitutional government of England. He clearly separates the functions of the executive and legislative powers, and eulogises the free English Constitution as the model worthy of universal imitation. The suggestiveness, the originality, the absence of dogmatism, and the remarkable brilliancy of its generalisations combine to make this "one of the most important books ever written." Even Macaulay, otherwise a rather severe critic of Montesquieu, admits that he "enjoys, perhaps, a wider celebrity than any political writer of modern Europe." And Count Grimm, writing in 1756, said, "The 'Esprit des Lois' has produced a complete revolution in the mind of the nation. The best heads in this country [France] for the last seven or eight years have been turned towards objects of importance and utility. Government is becoming more and more a matter of philosophic treatment and discussion."

The works of Rousseau and Voltaire were more directly responsible for producing the state of feeling that evolved the Revolution, but Montesquieu's writings had an immense influence on the finest minds and greatest men of his day by demonstrating to them the indefensibility of the despotic government they were living under.

As an older man, Montesquieu was particularly kind to humbler men of letters. In 1754, during a visit to Paris, he was taken ill with an attack of fever, and died on February 10, 1755. He was totally blind before his death.

SIR THOMAS MORE
The Prophetic Thinker of Tudor Times

Sir Thomas More, the most prophetic thinker of Tudor times, was born in London on February 7, 1478, the son of a judge, Sir John More. When a boy he was attached to the household of Cardinal Morton, the then Archbishop of Canterbury and Chancellor to Henry the Seventh. Then, as afterwards, he was universally admired and loved. "Whoever liveth to try it," said Cardinal Morton, "shall see this child, now waiting at my table, prove a notable and rare man." Later, Erasmus said, "When did Nature mould a temper more gentle, endearing, and happy than the temper of Thomas More?"

When he left Oxford and entered as a lawyer he was already known widely as an accomplished scholar. At the age of twenty-one he was a member of Parliament and Under-Sheriff of London; and although, in the words of Erasmus, "he tried as hard to keep out of Court as most men try to get into it," he was taken into the king's service, sent to the Continent as an ambassador, made a Privy Councillor, Treasurer of the Exchequer, Speaker of the House of Commons, and, in 1529, Lord Chancellor.

Henry VIII. was his friend, and an informal visitor at his home. When someone remarked to More how the King loved him, "Yes," said he, "but if the loss of my head would win his Majesty a castle in France I should lose it." When Henry made his last religious tack, and demanded that all Englishmen should acknowledge *his* supremacy in religion, More, who was, and had always been, a sincere Catholic, refused to take the new oath. "Item," says the diary of the Protestant Prime Minister, "to inquire the King's pleasure concerning Master More." The King's pleasure was that More should die, and, to the grief and amazement of Europe, on July 7, 1535, he was brought to the scaffold.

Thomas More lives for ever in a book which at one time seemed to have distilled into a word, and that a word of derision—the book "Utopia," the word "Utopian."

"Utopia" was written in Latin, and not translated into English until after More's death. The title of the first English edition, which remains incomparably the best, was "A fruitful and pleasant work of the best state of a public weal, and of the new isle called Utopia: written in Latin by Sir Thomas More, Knight, and translated into English by Ralph Robinson."

This new isle is introduced in a curious, non-committal way, that gives free scope for More's thoughts during a repressive and resentful age. He says that when he was on an embassage, Peter Giles, secretary to the Antwerp Council, introduced him to a strange mariner who had "sailed with Amerigo Vespucci under the equinoctial line," and, having seen many new lands, was wholly given up to the study of philosophy, particularly as regards laws and government. Sitting "on a bench of green turves" in More's garden, More, Giles, and the stranger, Raphael Hithlodaye, discuss how countries are governed, and might be governed, and the stranger proves to be so wise that they ask him why he does not become an adviser to kings. "Nay," he replies; "philosophy hath no place among kings;" and then he gives proofs, such as the punishment of theft by death, instead of removing the causes of poverty. Asked what those causes are, he replies: "High rents keeping an idle class, standing armies, large estates, luxurious living, and lack of education. Remove these, and there will be little cause for repressive laws, for the end of law intendeth nothing but the destruction of the vice and *the saving of the man.*" The world has taken four hundred years in learning that lesson. In enforcing these and similar thoughts the stranger harps on the good government of the Isle of Utopia, whereupon his hearers demand that he shall tell them of that government in detail.

In the fanciful sketch of a communistic government that follows, More foreshadows almost every reform and social improvement arrived at between his day and ours, and some that have not yet been attempted. He describes the division of the land into "fifty-four fair cities" about four-and-twenty miles apart; and the devotion of everyone to husbandry, but not as owners of the soil. These cities are laid out so as to be improvements even on our Garden Cities.

Every thirty families are grouped under a bailiff elected annually by the magistrates; every 300 families are under a magistrate, "who is not lightly changed;" every 200 magistrates *elect* a prince for life "*unless he be deposed on suspicion of tyranny*"—a bold proposal in the reign of Henry VIII. Every citizen learns some trade besides husbandry. Six hours a day is the time for work, and proves an abundance, for all men and women work, though the fittest for learning are dedicated to it by licence, as long as they make good use of the privilege. Food and all commodities are free and in common; no one lacks anything; and where all can have whatever they can use, there is no ostentation—which, says More, is the great curse of private riches. The hospitals for the sick are a forecast of the most modern institutions. Travel is arranged for, and emigration mapped out to distribute the population.

As examples of modern questions that have not developed beyond More's wisdom, law, education, and religion may be taken.

"For people so instructed, few laws suffice. They utterly banish all lawyers and such as craftily and subtily dispute of laws, for the simple and plain meaning of a law should be open to every man."

All in childhood are instructed in learning, whereas we allow our youths (says More) "to be wantonly brought up and infected, and then in God's name do punish them."

As for religion, the Utopian ideal should be written in letters of gold. "There be diverse kinds of religion, but the most and wisest part believe in a certain Godly Power, unknown, everlasting, incomprehensible, far above the capacities and reach of man's wit, dispersed throughout the world not in bigness, but in virtue and power. Him they call the Father of All. To Him alone they

attribute the beginnings, the proceedings, the changes, and the ends of all things. They believe that the soul is immortal, and, by the bountiful goodness of God, ordained to felicity. They believe virtue to be life according to Nature—and that Nature prescribeth to us a joyful life; to the body diverse sensible pleasures; to the soul the delectation that cometh of the contemplation of truth. But in all these matters they give every man free liberty to believe what he would, because it is in no man's power to believe what he list."

More's "Utopia" is obviously based on Plato's "Republic" in a broad way, but it is Plato made incomparably more practical, though admittedly some of its proposals are trivial. The central idea of the book's economy is the abolition of money, and with it envy, covetousness, want, ostentation, and Pride, the mother of mischief, and it closes with a passionate eloquence which shows how deeply the author believed in his ideals. Looking back at the troublous times in which More lived, when his dream was all of the future, we cannot but wonder reverently at its audacious beauty.

F. W. H. MYERS

A Notable Student of Human Personality

Frederic William Henry Myers was born at Keswick on February 6, 1843, the son of the Rev. Frederic Myers. After a distinguished school career at Cheltenham, he entered Trinity College, Cambridge, and was one of the most conspicuous scholars of his time. In 1872 he was appointed an inspector of schools, like another thinker and poet, Matthew Arnold. He wrote many essays and poems, and one of the best of the many critical volumes on Wordsworth, a poet who belonged to his native mountains. The following fragment of his poetry is worthy of quotation, for it exactly expresses the very essence of the thought of its author, and it also shows his interest in and sympathy with the leading ideas of modern science:

That hour may come when Earth no more can keep
Tireless her year-long voyage thro' the deep;
Nay, when all planets, sucked and swept in one,
Feed their rekindled solitary sun;
Nay, when all suns that shine, together hurled,
Crash in one infinite and lifeless world:
Yet hold thou still, what worlds soe'er may roll,
Nought bear they with them master of the soul;
In all the eternal whirl, the cosmic stir,
All the eternal is akin to her;
She shall endure, and quicken, and live at last,
When all save souls has perished in the past.

Frederic Myers was indeed a true poet, and a great man of letters, but here he concerns us as a thinker who not merely believed but reasoned, and added to the sum of human knowledge. As such he is to be remembered for two valuable achievements. He was one of the pioneers who founded and long served the Society for Psychical Research. He at last consented to become the president of the society, and held that office at his death, in 1901. The honest, patient, devoted, scientific prosecution of psychical research is incalculably indebted to Myers. But for him it is not possible that this subject should, in a comparatively short time, have been rescued from the charlatan and the fool, as astronomy and chemistry had been rescued before it, and should now be entitled to the place which it will yet receive among the acknowledged sciences. To have given this great subject its proper place in the estimation of the thoughtful, to have set its students upon sober, scientific lines, to have established what was looked upon as a "freak" society so that the greatest philosopher of the age is now its president —this was largely the achievement of Frederic Myers, and entitles him to a place among the epoch-makers of science.

His other great achievement is the tangible document entitled "Human Personality, and its Survival of Bodily Death," which was posthumously published in two volumes in 1903. A shorter version, made by the author's son in 1906, is of scarcely less value, and should be in every thinker's library as a classic of contemporary thought.

The task which Myers set before him was to furnish an exposition of the results of the new science which he had largely founded. The evidence was contained in dozens of volumes, and he was entitled to refer the student to them, just as the author of a volume on physiology gives references to individual researches and pieces of evidence. This obvious fact has been forgotten by many critics, who demand more evidence from the author, without troubling to study the evidence which exists, though so few people are aware of it.

Myers was, however, much more than a digester of data. He had real psychological insight. Recent students of insanity, and of sanity also, are spending all their time upon what they call "dissociation," or, in Myers's term, "disintegrations of

personality." The key to the phenonema of conduct, normal and abnormal, is to be found, they tell us, in the realm of the subconscious. Yet we have only to turn to an author of such eminence as William James to find him defining psychology, as "the science of consciousness."

It must be acknowledged that Frederic Myers was the first thinker to realise the importance of the subconscious. He, above all men, is responsible for directing the attention of modern psychology to a sphere of inquiry which has hitherto been ignored, or looked upon as trivial. And we are specially indebted to him for showing that the subconscious is important not merely in relation to disease, to morbid manifestations of mind and conduct, but also in relation to health and the highest manifestations of health, which are the noblest works of human genius. Myers's theory of the genesis of the products of genius was original and profound. Already it has become almost a commonplace of thought.

At Rome, early in 1901, Myers's physical resources began to fail. He suffered much before death, and his departure was described as " a spectacle for the gods ; it was most edifying to see how a genuine conviction of immortality can make a man indifferent to what to ordinary people is so horrible." Between the attacks of painful breathing, as he lay on his deathbed, he quoted these lines from an early poem of his own :

Oh, welcome then that hour which bids thee lie
In anguish of thy last infirmity !
Welcome the toss for ease, the gasp for air,
The visage drawn, and Hippocratic stare ;
Welcome the darkening dream, the lost control,
The sleep, the swoon, the arousal of the soul.

And thus, on January 17, 1901, Frederic Myers " died "—whatever that may mean.

SIR ISAAC NEWTON
Discoverer of the Law of Gravitation

Newton's stupendous genius is of a peculiarly attractive kind. It was an intent, patient, all-absorbing gaze upon reality—an ardent contemplation before which the deepest principles were gradually unfolded. This happy and most fruitful contemplation was in itself sufficient to Newton. It never occurred to him to do anything with it, or to teach or proclaim it ; his whole life consisted in this steadfast penetration into reality. So it came about that his outward life was entirely undeveloped—he remained a child to the end of his eighty-five years. His health, his domestic concerns, and all that was outside this pure intellectual flame had to be looked after by his devoted and unwearied relatives. He lived very frugally, and always in the same modest, calm, and dignified simplicity, together with a niece and her husband. He never married ; and, apparently, the thought of marriage never occurred to him.

Isaac Newton was born at the manor house of Woolsthorpe, near Colsterworth, Lincolnshire, on Christmas of 1642. His father, who survived the marriage by only a few months, was a small yeoman farmer ; he died at the age of thirty-six, before Isaac was born. At two years of age the infant was left at the manor in the care of his grandmother, for his mother married a second time, and went to North Witham, where her new husband was rector.

At fifteen years, Newton was taken from Grantham Grammar School and set to work on the farm, but it was soon apparent to everyone that he would never make a farmer. He was therefore permitted to return to school, and in 1661 entered Trinity College, Cambridge, as a sub-sizar. Within the next six years he had already laid the foundations of all his greatest discoveries, and the rest of his long life was spent in working them out. The principal monuments of his vast intellect are : the differential calculus, the law of gravitation, and the analysis of white light into its compound colours. All of these three discoveries, but especially that with regard to the law of gravitation, have been of incalculable service to the science of astronomy.

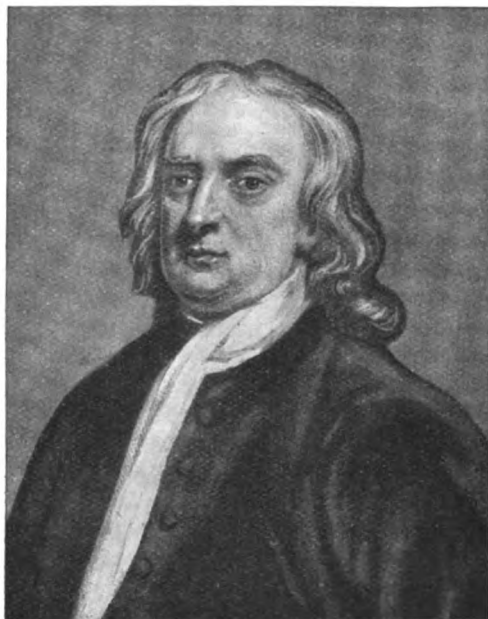
In 1665 the Plague swept over the country, and drove all Cambridge students away from the university. Newton returned to Woolsthorpe with his mind teeming with the problem of that central force which governs the solar system. It was clear that some single, definite force of that kind existed. Kepler's laws had proved that a central influence, emanating as it were from the sun, controlled all the motions of the planets ; that a similar force, or the same, emanating from Jupiter, regulated the orbits of his planets ; and, again, that the earth had a power of the same kind, by which to control the circling of the moon. So Newton saw the entire mechanism of the solar system in one simple and beautiful harmony. But this elusive force itself was still hypothetical, and thus failed to satisfy his ardent inquiry. The story of the falling apple, which struck home to his mind as he sat meditating on his great problem in the manor garden, appears to be quite authentic. The simple

incident threw, for him, clear light upon the whole order of the universe, and by it Newton understood the law of gravitation.

He did not, indeed, as is often stated, discover the fact of gravity, which had been recognised from the earliest times. Nor was he able, for many years after this event, to demonstrate precisely how gravitation is sufficient for the explanation of planetary motions. His first attempt was to apply his new idea to calculating the relations between the earth and the moon, but his results were unsatisfactory, because the generally accepted figures with which he was working happened to be incorrect. The result was that he abandoned the problem for many years, and applied himself to the study of optics, in which he became at once totally absorbed, in the manner characteristic of his extraordinarily sincere mind.

In the year 1672, however, the publication of Picard's correct determination of the length of a degree of the meridian, and therefore of the dimensions of the earth, provided him with far more accurate figures for his calculations, and he returned immediately to his suspended studies of the effects of gravitation, and this time with unqualified success. In complete silence, without taking anyone into his confidence, Newton worked out the whole theory of gravitation, as it affects the movement of heavenly bodies, in his immortal "Principia." The wonderful discovery became known only through Halley, who came to ask Newton to solve a certain problem relating to the path of a planet moving according to the laws which had been recognised by Kepler. Newton was able to explain the matter, and far more also, in the light of the lately discovered truth; and Halley, equally astounded and delighted, would not rest until the Royal Society had secured the publication of the epoch-making book. The "Principia" was, in fact, published at Halley's private expense, and, so far as we are able to know, would never have seen the light if it had not been for his disinterested efforts. The "Principia" is perhaps the most sublime mathematical work which has ever been written. Certainly it has had greater effect upon subsequent thought than any other. It was published in 1687; and a new edition, in the form in which it now appears, was given to the world in 1713.

Sir Isaac Newton's discovery of the composite nature of white light is also of the very first importance. He was attempting to improve the telescope, which at that time was a very inferior instrument, giving blurred colours round the image of a star. Its imperfect lenses had the effect of splitting up white light into the several component coloured rays. For a long time the phenomenon had been there for anyone to see and understand, but Newton was the first to understand it, and thus was undoubtedly the originator of the art of spectral analysis, which in the hands of Sir William Huggins and many of his successors has revealed the chemistry of the remotest stars.

Sir Isaac Newton was a very practical optician, and his improvements to the telescope are commemorated by the name "Newtonian," which is applied to the type of reflector which he designed.

SIR ISAAC NEWTON

In the year 1669, at the age of twenty-six, Newton was appointed Lucasian Professor of Mathematics at Cambridge. In 1672 he was elected a Fellow of the Royal Society, which was still in the ardour of its youth. After the publication of the "Principia," many irrelevant honours were thrust upon him; thus, in 1689 he was sent to the House of Commons, and in 1697 was appointed Master of the Mint.

Queen Anne knighted Sir Isaac Newton in 1705. He died on March 20, 1727, at the age of eighty-five, and was buried in Westminster Abbey. There is little doubt that he was the greatest mathematical genius who ever lived.

THE FIRST SOUND OVER THE ATLANTIC

The first sound ever heard through the air across the Atlantic passed by "wireless" between Cornwall and Newfoundland, where it was detected by Mr. Marconi and his assistants through a receiving kite.

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INVENTORS

SIGNOR GUGLIELMO MARCONI
The Harnessing of the Invisible Ether

SIGNOR GUGLIELMO MARCONI, to whom the world owes practical, commercial wireless telegraphy, was born at Bologna, Italy, on April 25, 1874, and was educated at Leghorn and at Bologna University, under Professor Righi. His father was a wealthy Italian, his mother an Irishwoman, and the blend of Latin and Celt has resulted in a unique type of mind—imaginative as of the seer, practical as that of the financier, indomitable as that of a Wellington.

Upon page 2033 of the present work begins a chapter in which the story of wireless telegraphy is told. Marconi's life-story and that of the science which he has brought to success are inseparable. Since he was a small boy studying under Professor Righi, his entire energies have been devoted to this one immense subject. He was fortunate, as Sir William Fothergill Cooke was fortunate. Cooke studied under a professor who happened to be fascinated with the problem of the then unborn electric telegraphy. Marconi came within the influence of a professor who was equally ardent in his gropings, not, indeed, towards wireless telegraphy, but to the mastery of etheric waves, tending to he knew not what. Others were experimenting in the same field.

Marconi's practical mind grasped the commercial possibilities of these waves. Gurney, Faraday, Clerk Maxwell, and Hertz had, by prophecy, by leading, by suggestion, directed, hastened, and aided the steps of practical men ; Preece, Lodge, Muirhead, Hughes, had actually telegraphed without wires, but nothing commercially practical had resulted. Marconi perceived that etheric waves might be used in telegraphy, as, long before, Gurney had seen that the oscillations of the magnetic needle might become a means of communication. But just as Jacquard feared to claim the reward for his invention, in the belief that so many other minds would have devised a similar machine, so Marconi found it impossible to believe that he alone had grasped the significance of the possibilities before him. Admittedly he had other men's work to go upon ; their labours were known to him, their appliances ready to his hand to do with as he would, but they were equally at the disposal of other men of scientific training, and he could not bring himself to fancy that the path to the desired goal was to be undisputedly his.

"Wireless telegraphy," as he says, "is, after all, only the practical application of a new way of controlling and detecting certain kinds of etheric waves, named Hertzian, to the useful purpose of communicating intelligence over sea and land without the employment of wires or other intermediary mechanical means. Although I was deeply impressed, owing to my experiments, with the value of the etheric waves given off into space under certain conditions of electrical disturbance, I could scarcely conceive it possible that their application to useful purposes could have escaped the notice of eminent scientists." And he sought diligently through all the technical papers and reviews, expecting daily to learn that his own theories had already found concrete expression in the achievement of some one man ; and not until he had failed to find that which he had feared he would discover could he let himself dare to hope that he and he alone had found a scientific new heaven and new earth. He did not know quite all there was to be known. He was not aware when he began, for example, of the wonders achieved by Hughes in a London street, for he has told us that when he commenced his experiments he was not able to effect a transmission across a space as wide as a

table-top. Hughes had had no difficulty up to 500 yards, years before. It was when he had succeeded, in 1896, in transmitting his signals to a distance of two miles that Marconi packed up and came to England.

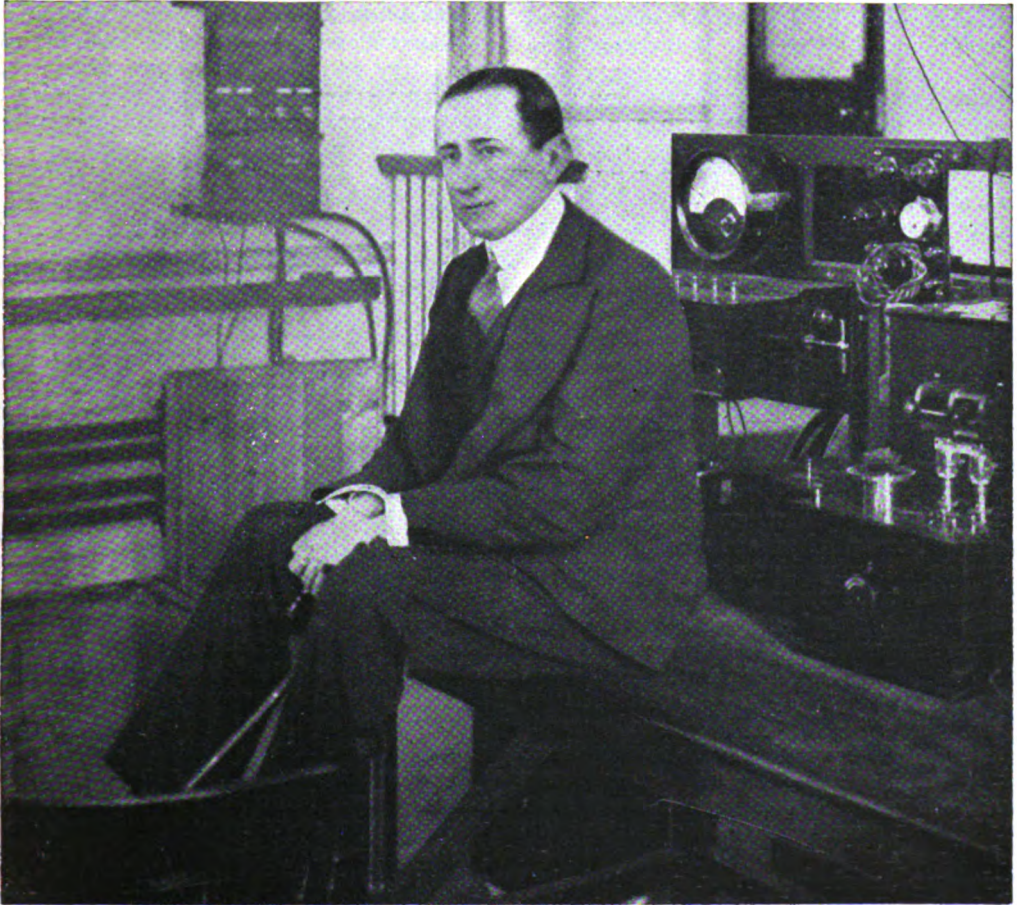
He was wise in choosing Sir W. H. Preece as the recipient of his confidences. When the telegraph cable was ruptured between Oban and the isle of Mull, in 1895, Preece had made no bones about the matter, but sent his messages without wires. With typical friendliness to new ideas, the same man had introduced both the telephone and phonograph into England. It was after his own wireless success that Sir William was waited on by Marconi, and he frankly confesses that "he brought a new method of working." That is the important point as to this stage of the development of wireless telegraphy. Preece was chairman at Marconi's first lecture; and though the veteran scientist was at first a little inclined, when messages began to flash across the Atlantic, to underrate the potentialities of the new creation, he magnanimously assisted the young stranger in the early days of his trials in England.

The story of Mr. Marconi's progress has already been told in these pages, but only he himself knows how anxious were the days and months that passed; how inexplicable for the time being some of the phenomena by which from time to time he was brought to a full-stop. One who worked with him during the days of trembling hopes and misty fears says, from his recollection of these times and the way in which Marconi faced his difficulties, "He has that intuitive perception of the solution of a difficulty to which the name of genius is properly applied."

The more his work progressed, the more puzzling became the results and obstacles. For example, there was nothing in the whole store of scientific knowledge to enable him to grasp the meaning of the now well-known "daylight effect." No one had ever previously projected a wireless signal far enough to discover that under the glare of a noonday sun a Hertzian wave travels a considerably shorter distance than does a similar wave with the same current at night. Had he confined his operations to work by day, he must have been defeated. It was only by contrasting night-effects with day-effects that he established the disparity, and it remained to him, the discoverer of the difference, to combat the difficulty. The problem was wholly unexpected, and at first apparently insuperable, but in a few months the apparent cause had been diagnosed, and a remedy put in operation.

Marconi had great confidence in himself all through his preliminary work. He succeeded in inspiring similar confidence in others. King Edward, when Prince of Wales, warmly interested himself in the young inventor, and rendered him invaluable aid by granting him the loan of the Royal yacht "Osborne," for experiments. When at last, on December 12, 1901, the first wireless signal leapt across the Atlantic, and the King was informed, he reminded the inventor that the good ship "Osborne" deserved the honour of sharing his success. The date mentioned is, of course, the red-letter day of Marconi's career. He had, in 1899, first established wireless communication between France and England, but now he had detected the arrival of the three little dots which, in the language of Morse, mean the letter "s." It was enough. The signal which, a few years before, had been too weak to hop the breadth of a little table had now bounded across an ocean—1800 miles—in the ninetieth of a second. A year elapsed before the first message proper was sent, and that came from the Canadian side, and, dated December 22, 1902, ran as follows: "To Lord Knollys, Buckingham Palace, London. On occasion of first wireless telegraphic communication across Atlantic Ocean, may I be permitted to present, by means of this wireless message, transmitted from Canada to England, my respectful homage to his Majesty the King?—Marconi." Quickly upon the heels of this came a similar message from Earl Grey, the Governor-General, to the King.

Since then wireless telegraphy has gone from strength to strength. Marconi has not escaped the tribulations common to the lot of pioneers. A cable company stopped his experiments in Newfoundland, and caused him to remove his apparatus from the country. A noted scientist doubted that his magic "s" had ever crossed the Atlantic by wireless means, and added, when messages proper began to fly across the water, that they could never compete with the cables; that the invention would never become practicable as an important means of communication. Actions in the Law Courts have had to be fought to establish the validity of Marconi's patents. The last and greatest of these occupied the Court no fewer than fourteen days. The judge, Mr. Justice Parker, held

that the Marconi patent was good and valid, that it had been infringed, and granted an injunction with costs, with an inquiry as to damages. Since then events at sea have conspired to fix in the public mind the extraordinary value of wireless telegraphy. At the beginning of the present year his system was installed upon the principal warships of the British and Italian fleets, upon some 300 ships of the mercantile marine and upon an increasing number of lesser vessels. History in wireless telegraphy has been made before the eyes of the youngest reader of this publication. All the details and difficulties have been watched as they arose and disappeared. Never was a great revolution effected with such speed and relative smoothness. The puzzles which beset the pioneers of the ordinary electric telegraph system are now forgotten, but it is interesting to recall that the incident upon which its rise in public estimation turned was the arrest of the Quaker murderer, Tawell. News of his flight by train from Slough to Paddington was wired along the line. The telegraph nearly enabled him to escape. The telegraph operator wished to wire "Quaker," but the telegraph had not yet got a "q" to its alphabet, and the operator had to spell out the word as "kwaker." The man at the receiving end was so long in deciphering the puzzling word that Tawell was all but clear away before the message could be passed on to the police. Mr. Marconi started with no such limitations.

SIGNOR MARCONI IN HIS WIRELESS STATION AT CHELMSFORD

H. GRINDELL MATTHEWS

The World as a Whispering-Gallery

Mr. H. Grindell Matthews commands a prominent place among the little group of scientists in England, America, Denmark, Italy, and Germany who are seeking to perfect a system of wireless telephony

which shall in course of time make the world one vast whispering-gallery. Mr. Matthews has been experimenting in the field for thirteen years, advancing step by step from the imperfect instrument to the less imperfect, gaining greater power for the transmitting apparatus, with accompanying increase of sensitiveness in the receiver. His first experiments were conducted in the quiet, unfrequented ways of country places, where he added mile to mile of the carrying power of his instrument. Later he gave a demonstration in a suite of rooms in a London hotel, through the intervening walls of which he sent his wireless words, distinctly and without difficulty, and after that sent his messages through half a mile of London streets. But all this was being done upon more ambitious lines by other inventors. Mr. Matthews seems to merit distinction by the inexpensiveness of his apparatus, and by the ease with which it can be fitted up and attuned.

The aerophone, as this telephone is called, was put to a severe test in the autumn of 1911, when for the first time it transmitted a message to a man flying in an aeroplane. The man in the machine clipped a receiver about his head, and while flying at some sixty miles an hour caught his aerophone message above the roar of the engine and the whirr of the propeller.

Mr. Matthews, who is known as the inventor of an electrically controlled torpedo, is confident that the aerophone, which is light and portable, and requires no " earth " or " antennæ," can be readily adapted for use on motor-cars and other light vehicles, in which case it should have value in time of war. But every motorist knows that such an instrument would be of great service in the foggy days of peace. The man who has driven a car in a mist and has heard, but been unable to see, another car approaching realises how welcome would be the service of an aerophone, or similar instrument, by which he could call a warning to the unsighted man who may be blundering straight for him.

It was the late Professor Ayrton who, when G.P.O. and other officials were saying that there never could be anything in wireless telegraphy, heartened the school of workers and thinkers of which Mr. Matthews is a conspicuous figure. " The day will come," said Ayrton, " when copper wires, guttapercha covers, and iron bands are only to be found in museums; when a person who wishes to speak to a friend, but does not know where he is, will call with an electrical voice, which will be heard only by him who has a similarly tuned electrical ear. He will cry: ' Where are you? ' And the answer will sound in his ear: ' I am in the depth of a mine, on the summit of the Andes, or on the broad ocean.' Or perhaps no voice will reply, and he will know that his friend is dead." Mr. Matthews is a pioneer of the science of which the lamented, far-seeing professor was a prophet.

HENRY MAUDSLAY

The Admirable Crichton of the Workshop

Henry Maudslay, a prolific inventor of machinery and one of the most famous of English mechanics, was born at Woolwich on August 22, 1771, the son of a mechanic who had been wounded and invalided out of the army. With no advantages of education beyond that of the workshop and the smithy, Maudslay became one of the greatest figures in the world of invention. He might have paraphrased Falstaff to say, " I am not only an inventor myself, but the cause that invention is in other men."

He began his career at twelve in the Woolwich Arsenal, first as a powder-monkey, then as carpenter's boy, next as an assistant in the smithy. The working of metals was to Maudslay a science to be loved. Hammer, iron, and anvil were to him tools as precious as palette, brush, and colours to the artist. There was no man in the works who could forge with such accuracy and finish as young Maudslay. The men recognised it, and the foreman, who knew that the lad was given to making things not within the official schedule, would, on approaching the smithy, be conveniently seized with a fit of coughing or sneezing in order that the hammering artist might hide the evidence of his occupation.

When Maudslay was eighteen, Joseph Bramah was rising to fame as mechanic and inventor, but was seriously handicapped by the lack of good tools and by the absence of skilful workmen, and, hearing of the doings of the lad at the Arsenal, he sent for him and put him to work. He had as good reason to be proud of his " find " as was Davy of his discovery of Faraday. Maudslay became his head man and right hand; invented the indispensable self-tightening collar for the famous hydraulic press, carried out the most complicated and delicate work for the admirable Bramah locks, and devised for him the first form of his (Maudslay's) invaluable slide-rest for the lathe. Bramah was a wonderful mechanic, but he did not appreciate his manager.

Maudslay, like many other good fellows, really loved his work; he was as enthusiastic as he was talented, but Bramah never paid him more than thirty shillings a week, which was a beggarly pittance for one who was probably the most gifted workman in the town. Maudslay was impelled by the needs of his little family to ask for an increase of salary. Bramah demurred, and, fortunate day for English industry, Maudslay left, took a little shop of his own, and put up a modest sign. His fame as a workman soon brought him trade, and his early struggles were of such a character that he was always able to look back upon them with genuine pleasure and pride. He began his career as a master in what was little better than a toolless world. Machine-tools were practically unknown; every sort of work had to be done by hand, and badly done at that. The advance in English mechanics dates from Maudslay's day. He had no tools, he had no dependable men. He created the first and trained the second.

His first great invention was the slide-rest, the parent form of practically all the wonderful machine-tools that succeeded it during the next half-century. The lathe had been in use from time immemorial, but all its operations had to be directed by hand. The slide-rest for the first time rendered handwork unnecessary, and accuracy a sine qua non. For the first time in the history of English mechanics it was now possible to do turning-work with speed and precision, and to produce any number of articles exactly alike in size and shape.

In our present age of machinery it is difficult to grasp the significance of the enormous advance which this simple device by Maudslay represented. Let Nasmyth, who was one of the Admirable Crichton's many illustrious pupils, declare in his own terms the meaning of the revolution. "It is not, indeed, saying at all too much," he writes, "to state that its influence in improving and extending the use of machinery has been as great as that produced by the improvement of the steam-engine in respect of perfecting manufactures and extending commerce, inasmuch as without the aid of the vast accession to our power of producing perfect mechanism which it at once supplied, we could never have worked out into practical and profitable forms the conceptions of those master-minds which, during

MR. GRINDELL MATTHEWS TALKING OVER HIS WIRELESS AEROPHONE

the last half-century, have so successfully pioneered the way for mankind.

"The steam-engine itself, which supplies us with such unbounded power, owes its present perfection to this most admirable means of giving to metallic objects their precise and perfect geometric forms. How could we, for instance, have good steam-engines if we had not the means of boring out a true cylinder, or turning a true piston-rod, or planing a valve-face? It is this alone which has furnished us with the means of carrying into practice the accumulated results of scientific investigation on mechanical subjects."

Among the first results of the invention was the execution by Maudslay of the elaborate block-making plant of machinery which Brunel had been commissioned to design for the Navy. The machines for the work formed a series numbering forty-four, and every tool, screw, spring, and lever in them was turned out of Maudslay's shop. After half a century's work the machines were running as well as the day they were made. The work set the seal on Maudslay's fame as an engineer. Many inventions now flowed from his fertile brain. He produced the first machine for screw-cutting. Prior to this every screw had had to be made by hand. Each screw would fit only one nut, and that badly. He was constantly improving old tools and inventing new ones. His own inventions enabled other men to become inventors, for he placed at their disposal implements without which their designs could never have been carried into effect. Great thoroughness, care, and finish characterised all his work, so that men could identify his products anywhere. "That's a Maudslay," they would say, picking up some tool of exquisite finish. He invented a machine which measured to the ten-thousandth of an inch, and the Whitworth "millionth measuring machine" was but a development of the same machine by his pupil.

He patented a method of regulating the supply of water for marine engines, so that the sea-water should not deposit its brine in the boilers, and so improved the marine engine itself that his firm supplied the Navy in this matter for many years. He devised machinery for flour-mills, for the Mint; machines for slotting and riveting metal plates. He had the grand faculty, in building a new machine, of realising what to do without; and his engines and other productions were always distinguished by what Nasmyth termed the "get-at-ability of parts," an art which builders of engines for motor-cars are now only just re-learning. In his biography of Maudslay, Samuel Smiles, to whom this article is indebted for data, tells us that the inventor's workmen regarded him not only with respect and admiration, but with great affection; and one old servant of the firm, talking of his master's supreme skill with all manner of tools, exclaimed: "Ah, but he was *splendid with an eighteen-inch file!*"

Maudslay was a man of huge frame and huge mind, who in every work that he undertook could teach his smartest men; and they knew it. Much of his time was taken up in designing, but he was always aglow with honest enthusiasm when he could go into his workshop, take up his hammer, and beat out the model for some new contrivance which was to be made. He would sit in his little workshop with the door of his library open, so that as he worked he might listen to the strains of musical-boxes set going to keep him merry. And in that small workshop he would hold a miniature Court. Brunel would drop in to talk over the shield that Maudslay was to make him for the Thames Tunnel; Chantrey would sit down and discuss with him plans for the casting of his immortal statuary; and Donkin would be there to work out with him the scheme for correctly dividing the standard yard measure. Maudslay would work and talk, telling tales of his early efforts, thinking aloud of the work that he was still to do. And in his workshops there were growing up young genuises of his own finding or selection who, under his fostering care, were to give British engineering that pre-eminence which it has ever since enjoyed. Half the mechanical inventions of the nineteenth century were cradled, directly or indirectly, in those workshops in Westminster Bridge Road, Lambeth; for, as Nasmyth has said, "To the tools of which Maudslay furnished the prototype we are mainly indebted for the perfection of our textile machinery, our locomotives, our marine engines, and the various implements of art, agriculture, and of war."

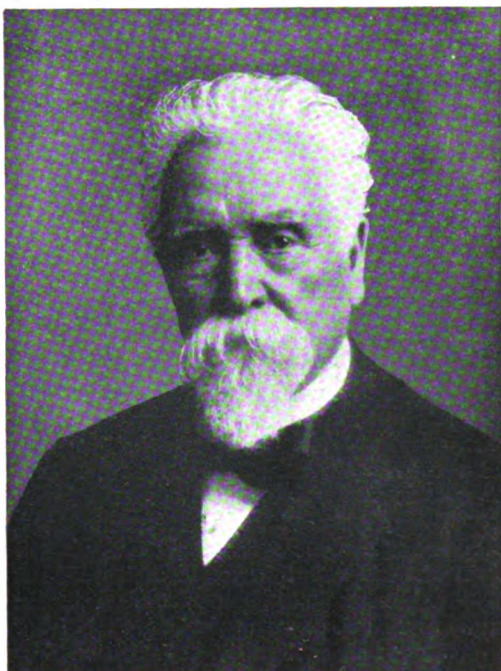
Maudslay's workshops were to British industry what the studios of the Old Masters were to Art in its renaissance; and from them emerged men such as Whitworth, James Nasmyth, Richard Roberts, Joseph Clements, Samuel Seaward, and William Muir. Maudslay died at Lambeth on February 14, 1831, and could have desired no finer epitaph than a passage which occurs in Nasmyth's writings describing his

methods. Referring to the benefits conferred upon mankind by the inventions of "that admirable individual whose useful life was devoted to the grand means of improving our means of producing perfect workmanship and machinery," Nasmyth says: "The indefatigable care which he took in inculcating and diffusing among his workmen, and mechanical men generally, sound ideas of practical knowledge and refined views of construction have rendered, and ever will continue to render, his name identified with all that is noble in the ambition of a lover of mechanical perfection." The world still has need of its Maudslays.

SIR HIRAM STEVENS MAXIM
The Man of Terror and Surprise

Sir Hiram Stevens Maxim, inventor of guns and explosives, was borne at Sangerville, Maine, on February 5, 1840. Apprenticed at sixteen to a carriage-maker at Abbott, he devoted his summers to work and his winters to school, until he was twenty years of age. During this time he made a tricycle, the wheels of which had the hub held in suspension by spokes in tension, the first of the kind, he says, ever seen in America. During the Civil War he was employed in the engineering works of his uncle, and afterwards at Boston, in the service of a maker of automatic gas-engines, for whom he devised several important improvements both in engines and in methods of carburetting air and oil-gas. Contrary to common report, he did not take part in the war; hence his automatic gun was not a product of battlefield experiences.

He took up the study of electricity with ardour, and, in autobiographic details supplied for the purpose of the present article, states that he was "the true inventor of the system of flashing which made incandescent lighting possible; that is, he discovered a process of building up and standardising filaments of electric light by heating them electrically in a highly attenuated atmosphere of hydro-carbon gases. He made the first regulator for keeping the pressure constant in an electric lighting system, quite independently of the number of lights on the circuit. This apparatus was exhibited in Paris in 1881, when he was made a Chevalier of the Legion of Honour."

Reaching London in 1883, he established himself in a small workshop in Hatton Garden, and there quietly worked out his scheme for an automatic gun. The mechanism of the gun is highly complex and ingenious, and a very remarkable production for a man who had had no previous experience of gun-making. The first cartridge is placed by hand in the breech, and after that the gun loads and fires itself; is, in fact, entirely self-acting. It did not emerge perfect at the first essay. The original Maxim gun was operated by the backward movement of the cartridge in the barrel at the instant of firing, a system which is largely employed in modern automatic pistols. This system, it was found, was not effective with the long, bottle-necked military cartridges. The inventor therefore designed a gun which worked by the recoil of the barrel and breech-block. When fired, the gun was

SIR HIRAM MAXIM

allowed to recoil one inch, and the energy thus developed performed all the functions of bringing the cartridges into position, transmitting them from their belt into the barrel, firing them, extracting the exhaust gases, and bringing the new cartridges into position. The invention aroused very great interest, and it was not until the first perfect gun had fired some 200,000 rounds that its reputation was established, for this innocent-looking machine fired from 600 to 700 shots per minute with deadly accuracy, and kept itself cool by means of a water-jacket by which the barrel was enclosed, while the gunner had nothing to do but aim. After the Maxim gun had

seen considerable service, Sir Hiram, not yet a knight, was in the company of the future Edward VII., about whom a host of notable men were clustered. "Sir," said the late Lord Salisbury, addressing the then Prince of Wales, "I have just been telling Mr. Maxim that he has prevented more men from dying of old age than any other person that ever lived."

Following his automatic gun, Sir Hiram turned his attention to heavier ordnance, and invented a gun which throws an aerial torpedo. It was thought at the time that the ordinary water-traversing torpedo would not travel accurately in a rough seaway, and his gun was designed for use when adverse sea conditions were to be apprehended. Every ship-of-war now has its water-tubes for torpedoes, but upon its deck is the gun which discharges a torpedo through the air. Many names are better known to the public in connection with the invention of explosives than that of Sir Hiram Maxim, but he has had a most important share in this field during the last twenty or thirty years. When he began his experiments the explosives used for ordnance were not invariably dependable; powders were apt to develop unexpectedly high pressures, and shatter guns. A slow-burning German powder, the invention of which was a secret, puzzled the experts, for upon chemical analysis it was found not to contain any new element. Sir Hiram, on taking up the problem, brought his microscope to bear, and found that the grains of nitre in the new powder, though small, were hundreds of times larger than the grains of nitre which had been employed in the English powder. Chemical analysis had led to the making of powder which produced high pressures and low velocities. Sir Hiram Maxim produced the desired combination, which gave low pressures and high velocities.

He followed this up, he tells us, by making, in the course of a single day, one hundred different kinds of powder, all of different degrees of slow burning. "The sulphur and charcoal were put into the mill and thoroughly ground and incorporated; the nitre was then added, and specimens were taken out as the process advanced. The first of these proved very slow; the last extremely violent." Subsequent research led to the invention of the first smokeless powder ever produced. The history of latter-day explosives is long and complicated, and embraces one or two important cases in the Courts, but "Engineering," an impartial and high authority, holds that, but for a legal quibble, Sir Hiram would have established his claim to be the originator of cordite. The patent for his explosive was taken out fourteen days earlier than that granted to Sir Frederick Abel and Professor Dewar; and it was only the turn of a single phrase in one sentence of his specification which enabled the Court to decide that the two compositions differed. The same journal declares that Sir Hiram Maxim was undoubtedly, on the evidence of the official records, the originator of the smokeless powder now in general use throughout the world.

Sir Hiram's next invention was a quick-firing gun of heavier calibre than his other destructive engine. The best then in existence required the attention of four men, and fired twenty-five rounds per minute. The Maxim quick-firer discharged forty rounds in fifty seconds, needed but one man, and, unlike some of its predecessors, caused no shock to the man behind the sights. The principle introduced was novel. In the inventor's words: "The novelty consists in placing the trunnions on a stationary sleeve, and allowing the gun to recoil inside the sleeve, with a hydraulic buffer interposed between the buffer and the sleeve. All the apparatus for training the gun is attached to the sleeve instead of to the barrels of the gun, thus completely eliminating the shock." The mounting of this gun, he adds, has since been adapted to practically every form of gun throughout the world.

At the age of seventy-one Sir Hiram Maxim retired from the company with which he had for twenty-seven years been associated, and announced his intention of returning to an old scientific love, aviation. He was the first man in England to build an aeroplane, but that was in 1889. Seeing how far the science has advanced it is interesting to note his description of his first machine, made in the year named. The machine that he developed and made was practically the same as the best machines of today, except that it was much larger, and was driven by a steam-engine instead of by a petrol-engine. It had the fore and aft horizontal rudders, as have the Farman machines of today, and the screw propellers rotating in opposite directions, as is the case in the Wright machines. This machine was 105 feet wide from tip to tip, and, with 600 pounds of water and three men on board, it weighed 8000 pounds. The engine-power was 360 horse-power. The screws were of wood, 17 feet 11 inches in

diameter, and collectively gave a screw-thrust of 2200 pounds, which propelled the machine along a railway track at the rate of forty miles an hour, and gave a lifting effect of over 10,000 pounds. The machine was, however, too large to be easily managed, and there was no room available in the neighbourhood. But it was the first machine in the world that succeeded in lifting itself from the ground with a man on board. Some day, when the early history of aeroplanes comes to be written, that little outline will be valuable.

OTTMAR MERGENTHALER
The Inventor of the Linotype

Ottmar Mergenthaler, the inventor of the linotype composing-machine, was born on November 10, 1854, in Durrmenz-Muhlacker, Würtemberg, Germany. His early training as a watch and clock maker admirably fitted him for the laborious and complicated work of inventing a machine for casting type and setting it up in one operation. Mergenthaler went to Baltimore in 1872, when but a lad, entered a machine-shop there, and by sheer ability worked his way up into a partnership.

He was thirty-two when he designed and built his first machine, in which the double operation of setting type and casting it in long leaden lines was performed simply by touching the keys of a board similar to the keyboard of a typewriter. Many men before him had attempted to construct a mechanical type-setter. Dr. William Church, of Birmingham, had patented, in 1822, a machine designed to cast types. The types were placed in reservoirs from which they were set free by pressing keys. After use the type was remelted, and so the problem of redistribution was overcome, but it was too expensive a way of solving the problem; and practically all similar inventions before that of Mergenthaler were hampered by the difficulty of distributing the type after it had been set.

Uncommonly ingenious was the device by which Mergenthaler eluded the difficulty of distributing the used type. He gained his end by using no type, and so having none to distribute. His machine is practically a type-caster. It consists of a vessel full of molten lead, from which types are cast as needed. Fonts of types are dispensed with altogether. This was the original thing about Mergenthaler's invention—the doing away with a magazine or font of movable metal types. He used instead the matrices or moulds from which types are cast.

The matrices are contained in a series of tubes above the keyboard.

A depression of a key causes the matrix to drop from the tube into an inclined channel, and on to a travelling belt to an assembler, where it takes its place in a line. When the line of matrices has been set up by striking the necessary keys, the line is properly spaced out, and carried in front of a slot of a wheel, connected with which is a pot of molten metal, kept hot by a gas-burner. Half a turn on this wheel forces out a charge of molten metal, and presses it into the incised letters on the matrices. The line is thus cast in a solid block, or line of type, from which comes the name "linotype."

An arm now comes down with a swoop from the top of the machine, and grips the matrices, and places them on a distributing-bar. This is most wonderful part of the mechanism; it is a kind of automatic intelligence. The matrices are forced along the bar by a worm-wheel, hanging on to it by a series of teeth. At intervals on the bar the teeth of the various matrices fail to grip, because of the way in which they are cut, and because the teeth of the bar alter in shape at various points. As each matrix loses its grip it drops into its own proper groove, and runs into its special magazine, ready for use again. No matrix can drop off the bar until it reaches its own box, nor can it be carried beyond the right place for it.

While the matrices are being distributed, the line of type is being dealt with. After the mould-wheel has ejected the metal, it returns to its position, and forces the cast line into a receiving galley. Here a little automatic arm holds all the lines in position until the "take" is full. The operator then lifts it out, and sends it away for proof, and starts at once on his next "take." The whole action of the machine is continuous. While the operator is setting one line of type on his keyboard, another is being cast, and the matrices are being redistributed as fast as he can use them.

At the side of the keyboard is a little lever, by which the operator introduces space-bands to divide the words and fill out the lines. The bands are of tapering thickness, and by means of them the spaces are made as close or as wide as needed. This automatic filling out of the blank spaces of a line is called "justifying," and for a long time it was thought that no machine could possibly do it. Mergenthaler's invention has made a single man a machinist, type-setter, justifier, type-founder, and type-distributor. All he has to do is to

finger his keyboard, as in typewriting, keep his melting-pot supplied with metal, and watch that the right matrices fall into line.

Mergenthaler's invention is the greatest revolution in printing that has occurred for four hundred years. In its modern form, the machine is a great improvement upon the original design. Probably more than 1500 separate patents have been taken out in connection with it. It is the result of a long succession of experiments and devices that were found to be necessary after Mergenthaler's original machine came into practical operation. The master-patent of Mergenthaler consisted in the use of a series of dies adapted for redistribution, together with a mould and a casting mechanism. His first machine was used in 1886 in the composing-room of the "New York Tribune," and some years passed before its original defects were remedied. When Mergenthaler died, on October 28, 1899, the linotype was a sound and powerful machine that was coming into general use.

SAMUEL MORSE

The American Inventor of the Telegraph

Samuel Finley Breese Morse was born at Charlestown, Massachusetts, on April 27, 1791, the eldest son of a minister. He graduated at Yale College in 1810, and there began at once to take an intelligent interest in electrical phenomena. He turned first to art, however, and, as Fulton had done nearly a quarter of a century earlier, came to London to study painting under his countryman Benjamin West, who, though over seventy years of age, was still vigorously pursuing his calling. Morse was successful, at the end of 1813, in gaining the gold medal of the Adelphi Society of Arts for his "Dying Hercules," and enjoyed considerable popularity as a painter.

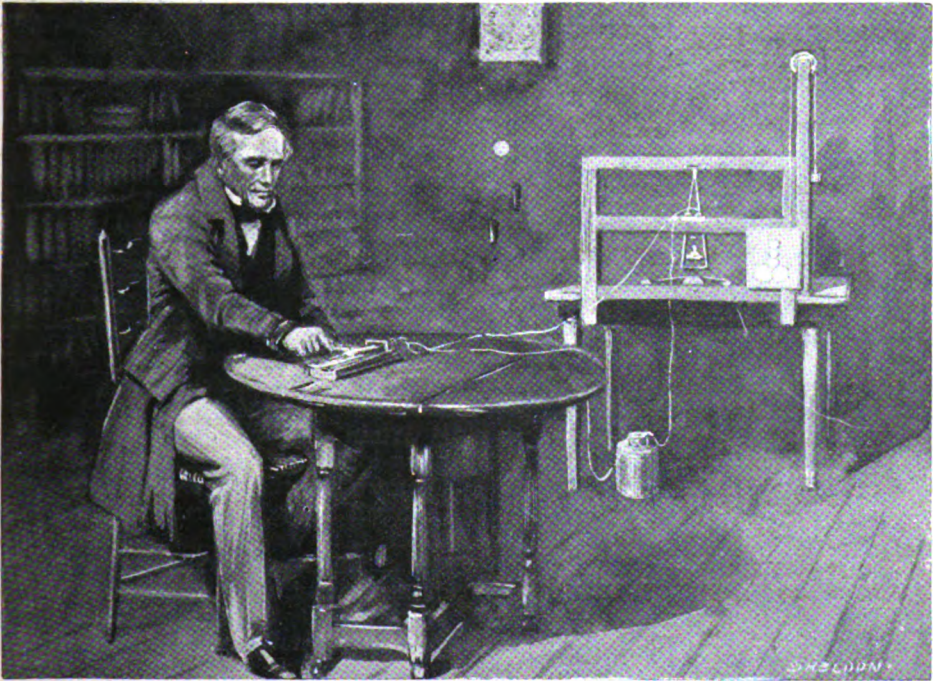
Returning to America, he founded the National Academy of Design, was its president for many years, and held the post of professor of arts in the university of the city of New York. Not until he had paid a second visit to Europe did Morse, who had never relinquished his interest in electricity, seriously begin to apply himself to its problems. It was on the voyage home from Havre to New York that he first expressed his belief in the practicability of an electric telegraph. He certainly understood the nature and properties of an electro-magnet, and explained, in the hearing of captain and passengers, the system he intended to try. Among the passengers on board that liner was a hazy personage who is declared to have had in his possession on board an electro-magnet. It is alleged to have been in his trunk, inaccessible in the hold. It is clear that Morse did not see it. Equally clear is it that Morse's sketches were made without knowledge of the hidden mechanism. Yet the validity of Morse's patent was afterwards challenged by this man of mystery, on the ground that he had explained his magnet to Morse! Upon reaching home Morse set to work in earnest upon his plans for a telegraph. He had a desperate struggle, and it brought him to abject poverty. Everything had to be made with his own hands—models, moulds, castings. He denied himself food and raiment in order to prosecute his experiments. For four years he could do nothing right. "I am crushed for want of means," he wrote. "My stockings all want to see my mother, and my hat is hoary with age." Five years from the beginning of his practical experiments he managed to complete his first little plant, and the New World, though it would not credit it, had got the electric telegraph.

He exhibited the marvel in the buildings of the New York University, in which he was still professor, and sent his signals through a circuit of six hundred yards of copper wire. He secured the qualified support of a New Jersey firm. Then he sought the patronage and protection of Congress, with a view to an official trial of his scheme over a distance sufficient to test its efficacy. A committee reported favourably, but Congress was too busy with stage-coaches and semaphores to trouble with this newfangled nonsense.

Meanwhile the inventor was in very serious need. He recognised, however, that he possessed the key to a revolution, so came to England to seek to patent his idea. But at about the time that Morse was exhibiting his telegraph to Congress at Washington, Wheatstone and Cooke were patenting in London their plan for "improvements in giving signals and sounding alarums in distant places by means of electric currents transmitted through metallic circuits"—and Morse did not succeed. Thus the twin marvels, telegraph and telephone, were both invented under corresponding conditions in respect of practically simultaneous origin in two quarters.

Morse was not more successful on the Continent, for, while France granted him a patent with one hand, she nullified it with the other. One important result did accrue, however. He and the friend accompanying

him carried as their dearest treasure the electro-magnet on which all depended. It was a huge piece of mechanism, weighing one hundred and sixty pounds. As it was carried about with extreme care, the two men were viewed with alarm and suspicion, in the belief that they were in possession of an infernal machine which might shatter a city or a sovereign. Happening one day to enter a public institution in Paris, they saw a coil of wire of the same form as their own ponderous apparatus. It weighed less than a hundredth part as much, yet performed the operation for which theirs was intended. Simultaneously with Morse's invention, an ingenious Frenchman had carried out the same idea, but with more success in the details. "Here is the essence of your magnet, presented in suitable proportions," remarked his friend to Morse. Upon examining the coil, they found it to consist of a vast number of convolutions of very fine copper wire wound with silk, the wire being not one-sixteenth of an inch, as in Morse's, but one-hundredth, thus giving the magnet intense power with small compass. The modification was at once adopted, and the electro-magnet in this form became the one employed for all the electric telegraphs in the world.

The invention continued to be pressed upon the notice of Congress, and at last, at midnight in the very last moments of the session, the sum of £6000 was appropriated for an experimental telegraph between Washington and Baltimore. That was in 1843. Morse's first official message was sent on May 24, 1844, and his tribulations were at an end. What Wheatstone and Cooke did for Great Britain, Morse did for the New World and for a great part of Europe. Moreover, he gave us our telegraphic alphabet. The Morse code of dots and dashes is in universal use for telegraphy, for wireless, for the heliograph, for flag signals, for flashes by searchlights and other illuminants at sea. Experts can even "wink" a communication in Morse.

SAMUEL MORSE MAKING HIS EXPERIMENTS IN TELEGRAPHIC TRANSMISSION

It is a striking fact that Morse was near a greater revolution than he knew. By accident he was led into a display of wireless telegraphy thirty-three years before Marconi was born! An unwary captain let go his anchor and dragged up the little electric cable in the water through which Morse had arranged to telegraph, for the purpose of a popular exhibition, from Governor's Island, New York, to Castle Garden, a mile away. Upon this Morse arranged his wires along the two banks of a stream, and resolved to try if the intervening water would act as a conductor. He carried out his experiment across a canal at Washington, in December, 1842,

and was perfectly successful, as he reported in a formal letter to the Secretary of the Treasury. Without intervening wire, messages travelled across the water from the transmitting instrument on one side of the canal to the receiver on the other. Similar results were obtained from trials across the Susquehanna River, a distance of nearly a mile. Morse's minute to the American Treasury makes interesting reading to-day: "Experience alone can determine whether lofty spars, on which wires may be suspended, erected in the rivers, may not be deemed the most practical." How near and yet how far "wireless" then was!

Morse sowed in tears, but he reaped in joy. He was in the end splendidly rewarded for his invention. He lived to see his system at work in the United States, in France, Germany, Denmark, Sweden, Russia, and Australia. At the instance of

MODEL OF MURDOCK'S LOCOMOTIVE

Napoleon III., in 1858, representatives of Austria, Belgium, France, Holland, Italy, Russia, and Turkey presented him with an international gift of £80,000, a handsome solatium for the ill-treatment he had received at their hands in the day of his need. Morse died, loaded with honours, in New York, on April 2, 1872, and is commemorated by a bronze statue in the New York Central Park, unveiled the year before his death.

WILLIAM MURDOCK
The Man who Gave us Coal-Gas

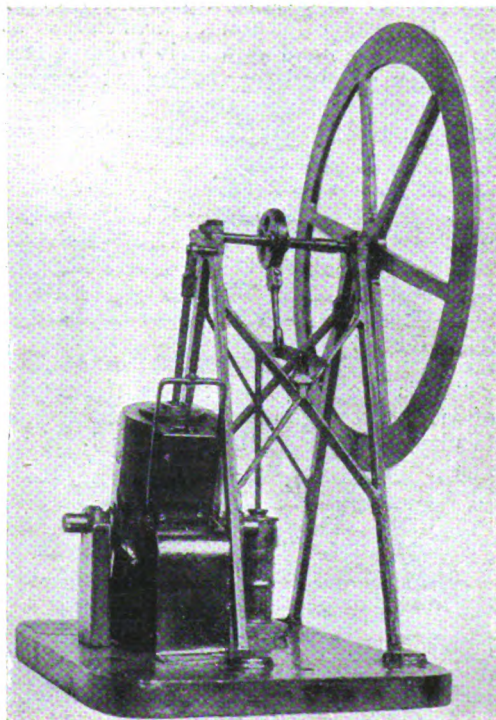
William Murdock was born at Bellow Mill, near Old Cumnock, Ayrshire, on August 21, 1754, the son of a cannie Scot, who combined a little farming and milling with the calling of millwright. Murdock helped his father in all three occupations, and while out tending the cows made himself a little hillside cavern, and scraped his way down to a surface stratum of coal, which he burned in a small stove of his own construction. He showed himself a capable mason; built a bridge over the River Nith, near Dumfries; and is said to have fashioned himself a wooden horse driven by steam, upon which he rode two miles to Cumnock.

When he was two-and-twenty, Murdock followed his countryman Watts to the Soho Works at Birmingham. Watts was down in Cornwall, and Boulton, who had heard shocking accounts from his partner of Scots workmen, was reluctant to engage him. While he was talking to the great man, Murdock, nervously twiddling his fingers, let his hat fall with a bang to the ground. Hearing the noise, Boulton remarked: "That seems a curious sort of hat. What is it made of?" "Timmer, sir." "Timber! Do you mean to say it is made of wood?" "Yes, sir. I made it mysel', sir, in a bit lathey o' my own contrivin'." It occurred to Boulton that a man who could make a lathe and turn a hat upon it might, after all, be worth retaining, and he engaged him at fifteen shillings a week when at home, with two shillings and three shillings extra for work in the country and London respectively, and for that sum got the services of one of the finest mechanical geniuses that Scotland ever produced.

Within a couple of years Murdock had proved himself so talented and trustworthy that the firm sent him down to Cornwall to take charge of the engines which they were building there. He was still getting a pound a week when the mines of the county, where steam was employed, practically depended upon him. Murdock gave the finishing-touches to steam-engines which the fine brain of Watt could not devise, and he made himself a king among the Cornishmen. The masters he won by his skill, industry, and unvarying good nature. Those workmen who were not placated by his lovable qualities, but sought to bully and harass him, he quelled by the strength of his good right arm. He toiled early and late, and at night they would hear him start up in his little bedroom, heave away at the bedpost, and cry, in his dream: "Now she goes, lads! Now she goes!" In his sleep he was working out steam-engine problems.

It was in 1784 that Murdock, while in Cornwall, produced his famous model steam locomotive. With that boyish glee which always distinguished and sustained

him, he would have his friends in at night and show them the little monster at work, drawing a truck loaded with the shovel and fire-irons round and round the room. One dark night, with the stealthy joy of a boy creeping to play during lesson hours, he took his engine out on to the road, lit the lamp by which steam was generated, and set her going. Off went the little engine, full steam ahead, with the horrified inventor panting in pursuit. The engine quickly outdistanced him, and from afar he heard cries of a person in the wildest distress. He raced on, and presently found that the sounds proceeded from the clergyman of the parish, who, going his lonely rounds in the dark, and suddenly finding a fiery monster charging full at him, had taken it to be the veritable devil in person. Murdock produced an infinity of inventions in Cornwall, and later, among them, the system of pneumatic bells with which his admirer Scott fitted up his new home at Abbotsford.

Murdock's whole life-story is a pleasing romance of inspired industry, free from the miseries and annoyances which soured and spoilt the careers of so many men like himself. Boulton and Watt carefully prevented him from advancing the steam locomotive, but we need not agree that it was done out of jealousy, as is often suggested. The fact is, the firm had so much need of "William's" genius in getting the stationary engine perfect that the partners honestly thought it better he should leave to others the "hunting of vain shadows," as they called it, and apply himself to the matter in hand. Murdock's work on the steam-engine is buried in the history of the invention, but his application of coal-gas to the purpose of lighting is happily less obscured. He had learned from his little hillside fire that the vapour given off by burning coal is combustible; and while at Redruth he filled a kettle with coal, fitted a tube and thimble to the spout, and lighted the gas which issued when the kettle was submitted to the heat of a fire. That was the beginning of coal-gas lighting. Upon disputed evidence it is stated that Murdock built a little retort in the yard outside his sitting-room, led the gas into the house by a pipe which entered by the window, and, with a system of pipes running throughout the office and his house, for ever banished candles and lamps. Moreover, he made little hand-retorts, so that he could carry a gas-lamp about to light him at his work and on his walks across the moors. When, in 1798, Murdock returned to Soho, the mineowners of Cornwall offered him £1000 a year to remain with them. It was at the Soho Works that Murdock first publicly exhibited his new illuminant, and at the celebration of the Peace of Amiens, in 1802, he lighted part of the exterior of the works. In the following year a portion of the Soho Works was lighted by gas, and within the next two years he had begun his first outside installation, for Augustus Lee, of Phillips & Lee, Manchester cotton manufacturers, who was the first man, other than the inventor, to have gas installed in his private dwelling. What Manchester thinks today, England does tomorrow. Gas-

MODEL OF MURDOCK'S OSCILLATING ENGINE

lighting gradually became an established success from that time forth. Murdock, industrious, fertile of invention, sunny-souled and generous, remained actively at work to the end of his days, and died at his house, within sight of the beloved Soho Works, on November 15, 1839.

JAMES NASMYTH

The Maker of the Great Hammer

James Nasmyth, the inventor of the steam-hammer which rightly bears his name, was born at Edinburgh on August 19, 1808. His father was Alexander Nasmyth, "the father of the Scottish school of painting,"

as he is called. The boy was educated by rather free-and-easy methods, as precisians would think, but the scheme worked admirably in his case, for it embraced unrestricted access to a little foundry and a chemical laboratory, while his father taught him drawing, for which he had a natural aptitude. But James Nasmyth, while a man of refined disposition, loved art not for art's sake so much as a means to mechanical ends. The man was born a mechanician, and it was when he sat down to his sketchbook that he evolved his most important inventions. Nasmyth thought in figured outlines. His father taught him, he tell us, to sketch with exactness every object, whether natural or artificial, so as to enable the hand accurately to reproduce what the eye had seen. Herbert Spencer suggests that, in order to cultivate presence of mind in children, we should encourage them rapidly to comprehend the nature and number of things momentarily seen. Alexander Nasmyth taught his boy to draw them. The point deserves some little consideration, for, if we are to accept Nasmyth's process of reasoning, the plan yielded him in after-life the shortest route to one of the most mighty inventions in the history of mechanics.

"It is one of the most delightful results of the possession of the constructive faculty," he says, "that one can build up in the mind mechanical structures and set them to work in imagination, and observe beforehand the various details performing their respective functions, as if they were in absolute form and action. Unless this happy function exists in the brain of the mechanical engineer, he will have a hard and disappointing life before him. It is the early cultivation of the imagination which gives the right flexibility to the thinking faculty." Nasmyth's own highly developed faculty for draughtsmanship was balanced by great expertness in the handling of tools. He was only seventeen when he invented his first steam-engine, a cheerful, fizzing little machine which ground his father's colours. Other engines served as models to illustrate the lectures he attended at the local mechanics' institution. There were not wanting men to appreciate his talent, and by these he was encouraged to widen the boundaries of his knowledge in more than the merely mechanical side of his calling. But it was his native talent that enabled him, as a boy of nineteen, to build the first steam-carriage seen on the roads of Scotland to carry half a dozen or more passengers. This he made to the order of the Scottish Society of Arts.

At about this time Nasmyth heard of the fame of rare Henry Maudslay, with whose career we have already dealt in these pages. Nasmyth, although he had genius of his own, was not too self-confident to place himself under the Englishman, and not too proud to toil for ten shillings a week and live on it. He became one of Maudslay's most zealous pupils, and has preserved for us a charming picture of the illustrious mechanic. His "dear old master," as he called him, dying in 1831, Nasmyth, after another year in the firm, set up a little shop of his own in Edinburgh. When a couple of years of tool-making and of jobbing mechanics had passed, he took his courage in both hands and opened a small foundry at Patricroft, Manchester. He was no dilettante; he was out to work, and embarked the whole of his little capital in the venture. It amounted to but threescore pounds, but it served; for in the course of a couple of years he was encouraged to launch out and lease six acres of land, and on it erect premises which became famous as the Bridgewater Foundry. Here, in partnership with Gaskell, he rapidly established a high reputation for the excellence of his work—steam-engines, machinery of all kinds, and machine tools.

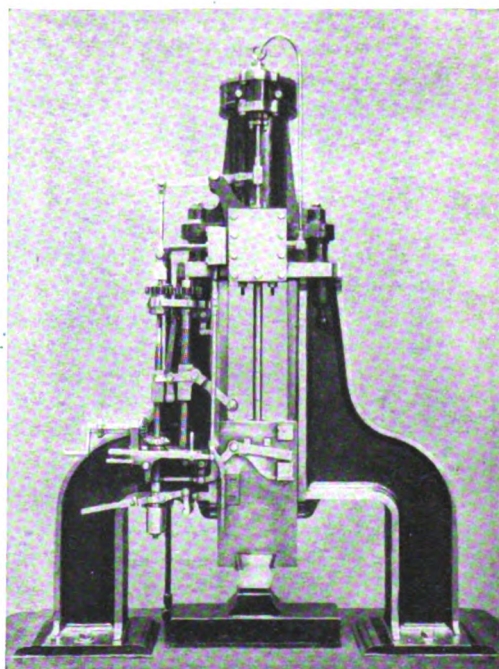
It was more as the inventor of implements for others than for anything else that his generation owed him thanks. This is not to disparage the value of his general output, which was of the highest merit, and did much to enhance the reputation of British engineering. But it required a special brain and aptitude to forge new mechanical powers for the engineer of the world, and Nasmyth's was the mind specially fitted for the task. Even had he built a thousand steam-engines he could not have conferred as great benefits upon industry as by the creation of a single steam-hammer. That was the gift to the world of an entirely new idea.

The history of the great tool is one of the romances of invention, and serves admirably to illustrate his claim as to the value of drawing. The idea of the hammer was suggested, not by his own observations, but by the need of another man. When the first of the big steamers, the "Great Britain," was in course of construction at Bristol, Francis Humphreys, her engineer, wrote to Nasmyth, telling him of a difficulty which had arisen. He required a wrought-iron intermediate paddle-shaft of

a then unprecedented size. He had applied, he said, to the largest firms throughout the country for tenders, but to his dismay found that not one of them could make a forging of the dimensions specified. "What am I to do?" asked the engineer. "Do you think I might dare to trust to cast-iron?"

The reason why the then existing hammers could not forge a thirty-inch shaft was that they were constructed upon a wrong principle. They were so designed that when a large object requiring the heaviest blows was laid upon the anvil, they then became the weakest. The space through which the hammer ought to have descended was already occupied by the metal to be forged. Nasmyth sat down to think into his sketch-book. The obvious remedy, he saw, was to design a method by which a ponderous block of metal should be raised to a sufficient height above the object on which it was desired to strike the blow, and then let the block fall upon the forging, guiding it in its descent by such simple means as would give the required precision in the percussive action of the falling mass.

"Following out this idea," he says, "I got out my scheme-book, on the pages of which I generally thought out, with the aid of pen and pencil, such mechanical adaptations as I had conceived in my mind, and was therefore enabled to make them visible. I then rapidly sketched out my steam-hammer, having it all clearly before me in my mind's eye. In little more than half an hour after receiving Mr. Humphreys' letter narrating the unlooked for difficulty, I had the contrivance in all its executant details before me in a page of my scheme-book. The date of this first drawing was November 24, 1839." It is unnecessary at this stage of our industrial development to describe the famous hammer, which, at the will of the operator, pounds colossal masses of metal as a potter pounds his clay, and yet is so perfectly under control that it can be made to crack the glass of a watch without damaging the watch, or to split an eggshell without hurt to the wineglass in which it is contained.

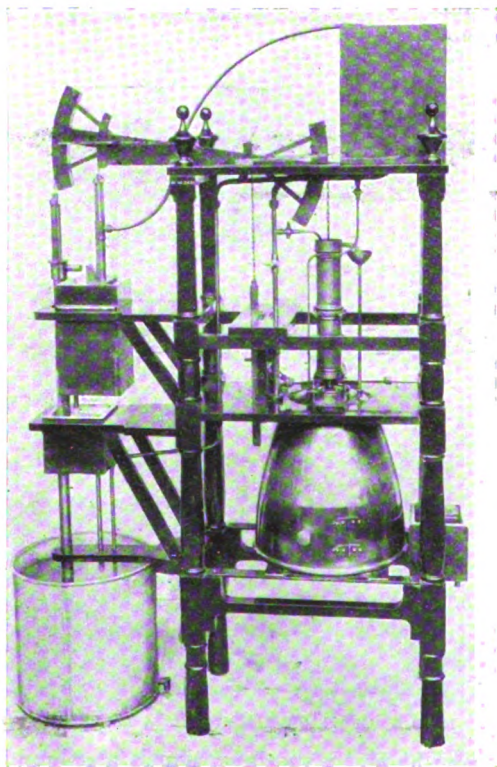
Called into existence to meet a want for the "Great Britain," the steam-hammer was never used for that purpose, for it was decided afterwards to substitute the screw propeller for paddle-wheels. Nasmyth did not therefore proceed at once with his invention, but showed his plans to visitors at his works. One of these visitors was the head of the great Creuzot engineering firm of Schneider; and the first Nasmyth heard of a steam-hammer in being was upon the occasion of a visit to Creuzot in 1841. There was his invention at work, and called the Schneider hammer. Very foolishly he had neglected up to this time to patent his idea, but he now made haste to do so, and set up his first steam-hammer at his works in 1843. From it he evolved the steam pile-driver, a steam-hammer for dressing stone, and adapted its principle to marine steam-engines. Engineering practice has undergone a remarkable change since the invention of the steam-hammer; and it should therefore never be forgotten that, although a filched idea from a too-confiding inventor enabled a foreign maker first to erect a

MODEL OF NASMYTH'S STEAM HAMMER

steam-hammer, the invention is absolutely British. Nasmyth, who, after retiring from business achieved notable results in astronomical research, died on May 7, 1890.

THOMAS NEWCOMEN

A Pioneer of the Steam-Engine

Thomas Newcomen was born at Dartmouth, and baptised there on February 28, 1663. Enrolled among the immortal inventors, Newcomen has left very little of biographical data behind him. Absolutely nothing is known of his youth or training, and there is a doubt as to whether he followed the occupation of ironmonger or blacksmith. Associated with him in his

improvement of Savery's primitive steam-engine was one John Calley, of Dartmouth, but there is nothing to indicate that he was more than a sleeping partner in the great enterprise. It is suggested that Newcomen had read of the experiments of Papin with steam; but how a man in humble circumstances, such as Newcomen's, was to gain access to the writings of a French physicist is not clear. There seems more probability in the story that he was engaged, as one of the few competent workmen in the neighbourhood, to assist in erecting the steam-engine set up by Savery at Modbury, some

MODEL OF NEWCOMEN'S ENGINE

fifteen miles distant from Dartmouth. But as to this there is no certainty, for Switzer, in his "Introduction to a System of Hydrostatics and Hydraulics," says that Newcomen was as early in the field as Savery, adding that the latter, "being nearer the Court, had obtained the patent before the other knew of it; on which account Mr. Newcomen was glad to come in as a partner."

Another not impossible story is that, having some general idea of Savery's engine, Newcomen made a model of it, discovered in the model the weaknesses of the original, and proceeded to remedy them by the invention, or rather adaptation, of the piston, which was, indeed, as old as Hero. Newcomen is said to have corresponded with Robert Hooke upon the subject, and to have been dissuaded by Hooke from making an engine on the Papin principle. Hooke is stated to have added the important hint, "If Papin could make a speedy vacuum under your piston, your work were done."

Newcomen's first engine, which may have been the model already mentioned, lacked the piston. The history of the Newcomen engine is told on page 3605 of the present work. Here may be added the story of the invention of the jet of cold water introduced into the cylinder to cause a rapid condensation of the steam upon which the whole work of the engine depended. The first engine erected for work by Newcomen lacked this jet. The cylinder was cooled by the application of cold water to the exterior of the cylinder—a wasteful and primitive scheme. Every effort was made to keep the cylinder free from water, but the wearing of the piston caused a leakage of water from the supply maintained upon the head of the piston for the purpose of keeping the latter air-tight. As the water percolated through the aperture, Newcomen noticed that the engine worked much more satisfactorily than before. His native genius enabled him swiftly to grasp the significance of the lesson. He introduced forthwith a modification whereby he could throw a jet of cold water into the cylinder, so causing a rapid condensation of steam without chilling the entire exterior of the cylinder and occasioning a waste of heat in the motive power. "His Majesty Accident" has many gifts to bestow upon ready hands, and Newcomen's were ready.

It is a curious fact that Newcomen, who, although always subject to the domination of the more favoured Savery, was truly the father of the practical steam-engine, never took out a patent. Invention to him, as to many other of our geniuses, was a bread-and-cheese matter; and although the efforts he made to get his invention adopted show that he appreciated its value to mine-owners, yet he could not have realised the enormously important gift that he was presenting to the world. In saving for the mining industry of this country coal and metals to be won from deeper and deeper levels in workings which had become mere gathering-grounds for water, he rendered available supplies of inestimable raw

materials which gave Great Britain an incomparable advantage over her Continental rivals. Newcomen is believed to have died in London in August, 1729.

JOSEPH NICÈPHORE NIEPCE
The Father of Photography

Joseph Nicèphore Niepce, the father of photography, was born at Chalon-sur-Saone, in France, on March 7, 1765. His father was a man of wealth and position, being one of the king's judges; and as Niepce was a dreamy, imaginative lad, with no particular inclination to a calling, he went his own way all his early work is now obscured and forgotten, and his name is entirely associated with the invention that occupied his last twenty years, and absorbed the fortune he had inherited from his father. Lithography had been recently invented by Senefelder, and Niepce was much interested in the process, and aimed at improving upon it. At first he replaced the stone by a plate of tin, and in 1813, while he was trying to find a substitute for the lithographic chalk with which the designs were drawn, the fantastic idea struck him that the picture might be painted by the light of the sun.

THE DISMANTLING OF AN ORIGINAL NEWCOMEN ATMOSPHERIC ENGINE THAT PUMPED UP WATER 200 FEET FOR 120 YEARS AT TANFIELD MOOR COLLIERY, DURHAM

until the Revolution broke out. But in 1792 he entered an infantry regiment as sub-lieutenant, and saw active service in Italy. Failing sight and ill-health compelled him to resign his commission, and in 1794 he was appointed a member of the administration of the district of Nice. This position he held till 1801, when he returned to his native place, and devoted himself to the scientific research that had become his chief interest.

Several of his mechanical inventions and discoveries in dyeing attracted notice, but

Niepce was acquainted with the camera obscura, in which a picture was formed by a lens in a little, dark chamber. Many amateur artists of the day used this contrivance in learning to draw scenery. They went over a little sunlight picture with a pencil, popping their heads through a cloth at the back of their portable box, somewhat in the manner of a photographer focussing an object. Niepce saw that if he could find some chemical that would change under the action of the lights and shades the sun-picture projected

through the lens, he would be able to take photographs.

He tried one of the silver salts that blacken when exposed to light, but he could find no way of fixing the picture he so obtained. He then discovered that asphalt, or bitumen of Judea, a substance found in the Dead Sea and other places, possessed the quality of becoming soluble in oil of lavender. He poured a solution of this bitumen upon a metal plate, so that it covered the surface, and dried in the form of a brown film. He placed the coated plate in a camera obscura, at the spot where the image from the lens fell, and then exposed it to the light. The result was that the asphalt remained soluble on the shadowy parts of the image, but became fixed on the light parts. These changes were not visible to the eye; but when the ingenious Frenchman poured some oil of lavender on the plate, it dissolved the parts that had not been changed, leaving behind those which had been affected by the light and made insoluble.

Thus Niepce obtained his first photograph—a picture drawn by the sunlight upon a metal plate in lines of asphalt. An exposure of several hours was needed to obtain this first sun-picture, owing to the fact that the asphalt was very slowly affected by the light-rays. Niepce, however, was still only thinking of improving the process of lithography. By soaking an original drawing, or a print, in oil, and making the paper transparent, he was able to place it in a strong sunlight upon his asphalt plate and make a reproduction of it. All the black lines remained unaffected, and were washed away with oil of lavender, leaving the white spaces still covered with bitumen. Niepce then poured on the copper plate a corrosive acid that ate into the metal wherever the bitumen had been removed, and so left an etching of the original design. The copper plate could then be used for printing off a number of impressions in the ordinary way. These impressions Niepce called "heliographs," and he seems to have succeeded in producing them in 1826. In an improved form his method is still used in some countries for printing banknotes.

Niepce, however, was dissatisfied with the result, and he took up another line of research. He used a highly polished silver plate, thinly coated with asphalt dissolved in oil of lavender, and treated with iodine. In 1829 he entered into a partnership of invention with another Frenchman, L. J. M. Daguerre. The two men began to search for some chemical more sensitive to light than asphalt, and it turned out that the iodine that Niepce had been using with his silver plates was the very thing that was needed. Niepce himself died in 1833, and Daguerre took all the credit for the discovery of the iodine process, and the photographs so obtained were called, after him, "daguerrotypes." It has been asserted that Niepce, a trustful and unworldly man, was robbed of the honour of his invention by his sharper and more businesslike partner. But this is putting the matter too strongly, for Daguerre undoubtedly took a part in the perfection of the iodised silver plate process. Yet one cannot help feeling that he acted rather ungenerously in giving his name exclusively to an invention which was only his in part, and that part perhaps a small one.

Niepce's death and the secrecy he maintained in regard to his new process make it now impossible to discover exactly how much of the final achievement was actually his. The announcement of the discovery of modern photography was made by Arago, the celebrated astronomer, on January 9, 1839. In consequence of representations made by him, the French Government arranged for the process to be purchased by the State and made public. Daguerre was given a pension of 6000 francs, and Niepce's nephew received 4000 francs a year. The nephew discovered the radio-activity of uranium, but failed to pursue this wonderful phenomenon.

ALFRED BERNHARD NOBEL

The Peaceful Triumphs of Warlike Inventions

Alfred Bernhard Nobel, the inventor of explosives, was born at Stockholm, Sweden, on October 21, 1833. The son of a skilful mechanician, who removed with his family to St. Petersburg, there to carry out the manufacture of torpedoes, Alfred Nobel, whose name will be perpetuated by his Peace Prize and other awards related to the humanities, was bred to thoughts of munitions and implements of war. When Nobel senior returned to Stockholm, and began the manufacture of nitro-glycerine, Alfred, then seventeen years of age, accompanied him as assistant. Seven years later the son chanced upon one of those extraordinary accidents which now and again carry men to fortune. Some nitro-glycerine escaped from a cask in which it was contained, into the siliceous sand in which it was packed. Nobel was a born chemist; he teste designed and accidental compounds

and combinations of explosive substances as Simpson tested drugs for possible anæsthetising properties, as Edison experimented with combustible substances for the making of his incandescent filaments. And resulting from his experiments with the nitro-glycerine which had leaked into the sand, he discovered and named—dynamite.

Of course, the whole process was not a simple matter. It was the issue of a long series of experiments of the most dangerous kind. Nitro-glycerine, in which the explosive properties reside, had earned an infamous name. It had caused so many terrible accidents that its use for blasting had been prohibited in England and in two or three other European countries. Its powers were enormous, but it absolutely lacked dependability. Dynamite was the first form in which it could be used with relative safety. Even while this note is being written, the utter demolition of a British ship in an American harbour, with a casualty list of a hundred, suffices to prove that dynamite is still to be handled only with the extremest care. Its disruptive powers are about eight times those of gunpowder. Yet those accustomed to its use aver that it is far more safe to handle.

If accident gave Nobel dynamite, a bow at a venture would seem to have yielded him blasting gelatine. While dressing a cut with collodion—which is the product of gun-cotton dissolved in ether—he poured the residue of the bottle into some nitro-glycerine. The surprising gelatinous result led to a series of experiments from which the blasting gelatine of commerce issued. This is an explosive half as strong again as dynamite, and employed for work where greater disruptive power than that possessed by the earlier substance is demanded. The success of the new compound was demonstrated by the blasting operations for the St. Gothard Tunnel, the rock to be removed there being practically proof against all ordinary explosives. Nobel produced smokeless powder for military purposes, improved gun-building, and was a pioneer in the development of valuable oilfields.

He accumulated a fortune of over two millions sterling, which he left invested, the income to be devoted every year as prizes to those, irrespective of nationality, who have, during the current twelvemonth, made the most important discoveries in physics, chemistry, or physiology, or have written the best literature or contributed most to the cause of international brotherhood, in the suppression or reduction of standing armies, or in the establishment or furtherance of peace. This is quite one of the most remarkable bequests in modern times, and the annual awards are awaited with greater interest than almost any other known honours list. The will of Nobel suggests the spirit manifested by Napier when, on his deathbed, he was asked to explain the secret of his terrible machine for the slaughter of an army. But Nobel's work for peace was not confined to this great legacy. Although he was devoted for a great part of his life to the creation of implements of war, his inventions have had an inestimable effect in promoting the ends of civilisation.

He has blown railways through the heart of mountains, has made harbours on inhospitable coasts that shelter the argosies of commerce as well as the powerful vessels of war; he has given the farmer a new implement for breaking up his ground and for the uprooting of tree-stumps that formerly made cultivation impossible. He has given the road-maker, the mine-proprietor, and the contractor a power such as they never before possessed. He has enabled us to lessen the gradients for railways and for road traffic, so that now we can at last eclipse the Romans as makers of highways. Canals and docks result from the explosion of his dynamite, rivers become navigable by the same treatment. Dynamite, the product of a terrible vehicle of destruction, has become a disciplined force which is now indispensable to the engineer and maker of tunnels and highways. The man who gave the world this new power did so as the result of the most hazardous trials and thrilling dangers.

The factory in which he carried out his experiments was shattered to atoms, and the work, up to the time that perfection was attained, was attended by constant peril and menace. While carrying out these investigations Nobel was practically a chronic invalid. His intimates described him as physically weak, of a nervous, high-strung, and exceptionally sensitive disposition, balanced, however, by indomitable will-power, which carried him without flinching through the deadliest dangers. On one occasion when some dynamite could not be removed from a large cask, he crept into it and dug the explosive out with a knife. Nobel, who lived to see works for the production of his explosives established under Government supervision in Scotland, and his business extending to the uttermost ends of the civilised world, died at San Remo, Italy, on December 10, 1896.

WHEN THE SEVENTH DAY WAS THE DAY OF POPULAR ROYSTERING AND DEMORALISATION

SCENES WHICH SUGGESTED THE URGENT NEED FOR SUNDAY-SCHOOLS TO ROBERT RAIKES THE PHILANTHROPIC PRINTER OF GLOUCESTER

CONTINUED FROM 4821 CONTINUED ON 5069

PIONEERS

ROBERT RAIKES

The Founder of Sunday-Schools

ROBERT RAIKES, son of a Gloucester newspaper owner, was born at Gloucester on September 14, 1735. Blessed with means and a generous disposition, Raikes, as he grew up, was led to interest himself in the terrible conditions of the poor in his native city. In their squalid homes, in the dismal streets, in the hideous prisons of the period, they lived lives little better than wild animals. The lot of the children of such parents was appalling. Elizabeth Fry was not born when Raikes began his mission, and all the horrors of our penal system conspired against the happiness and weal of the little ones. Hunted from pillar to post in the streets, homeless and unbefriended as John Pounds found them in Portsmouth, they were driven to petty crime, and hauled to prison, where, with no provision made for them, they would have perished but for the charity of the senior offenders, who, bad as they were, would share or even sacrifice the whole of their rations to preserve the infant malefactors from starvation. The conditions of child life simply manufactured crime.

Raikes, going one day to a part of Gloucester with which he was unfamiliar, was horrified at the sight that met his view. He was informed, however, that on the Sunday "the street was filled with a multitude of wretches, who, having no employment on that day, spent their time in noise and riot, and cursing and swearing in a manner so horrid as to convey to a serious mind an idea of hell rather than any other place." There had been Sunday-schools long before the day of Raikes, here and there, spasmodically supported, never consistently conducted. Raikes is said to have had the idea suggested to him from a variety of sources. No matter what the origin, the results were his. He organised and coordinated effort, and gave the movement an impetus which it has never since lost. He began by engaging four women who kept dame schools to give instruction on Sundays to such children as he might send them. The teaching was at first mainly secular. It was the only teaching that the children of the poor received. Thousands of men and women in England grew up with no more schooling than they received upon the Sabbath from the lips of the devoted men and women who gave their one day of rest to this work. But at the outset the idea of voluntary service did not occur to Raikes. He paid his first teachers one shilling each for their labours. There was no difficulty in getting scholars. The first classes ranged in age from six to fourteen years, and Raikes left it on record that he stipulated only for personal cleanliness, "All that I require," he told his protégés, "are clean hands, clean faces, and the hair combed." It seems little to ask, but the conditions were not easily complied with in the case of many of the children. Once a month the children attended church to be catechised upon their religious knowledge.

The system of these first regular Sunday-schools was different from that with which children of a later generation have become familiar. The schools opened at eight in the morning, and lessons began half an hour later, and the scholars then either returned to their homes, or went to church service. They reassembled after dinner and remained at school until half-past five. Young England had begun to spell and sum, and, for one day in the week, at any rate, to perform its ablutions. The effect in the town was marked, and one man of note affirmed that "the change could not have been more extraordinary had they been transformed from the shape of wolves and tigers to that of men." The scheme became talked of and began to spread about the country. Raikes wrote of it in his paper, and his article, though anonymous, attracted immediate attention. The new idea was discussed in two of the leading magazines of the day, and from that time forth the success of the Sunday-school as a

national institution was firmly established. Sunday-schools spread over the land with a rapidity for which it would be difficult to find a parallel in any other movement.

At first the question of teachers' salaries threatened to embarrass the plan, but by-and-by a number of enthusiasts banded themselves together vowed to voluntary service. It is said that this laudable innovation had its rise at Oldham. It was near by, at Bolton, apparently, that Wesley, who heartily approved the scheme, first made acquaintance with it, for he writes in his journal for April 19, 1788, of a service in the latter town: "And this I must avow, there is not such a set of singers in any of the Methodist congregations in the three kingdoms. There cannot be, for we have near a hundred such trebles, boys and girls, selected out of our Sunday schools and accurately taught, as are not found together in any chapel, cathedral, or music-room within the Four Seas. Besides, the spirit with which they all sing, and the beauty of many of them, so suits the melody, that I defy any to exceed it; except the singing of angels in our Father's house." Sunday-schools were only eight years old when the marvellous veteran of four score and odd wrote that generous praise.

The schools grew in number and influence throughout the life of Raikes. News of them reached the Court, and attracted the favourable notice of the King and Queen, who sent Fanny Burney down to Gloucester to see the man who had wrought the miracle. Fanny's characterisation of the flustered philanthropist is not altogether charitable. When he had shown her the reforms he had effected she tells us: "I poured forth my satisfaction in them very copiously and warmly. He hinted a question whether I could name them to the Queen. 'Beyond doubt,' I answered; 'for these were precisely the things which most interested her Majesty's humanity.'" The joy with which he heard this, she says, was "nothing short of rapture." But though the lively Fanny found him "somewhat too flourishing, somewhat too forward, somewhat too voluble," she had to admit that he was "worthy, benevolent, good-natured, and good-hearted." And posterity has adopted the latter part of her verdict. His work is the epitaph by which he may be judged. Few men have ever done more for a nation than Robert Raikes. He did but prepare for the greater reforms which were to follow. But he began the teaching of young England, and by instructing the hapless little ones of his own generation, he taught them how to help themselves when they were grown men, and he was in his tomb. The reforms for which they were later to fight and suffer would never have been demanded had they not received learning enough to realise the dire wrongs and misery of which, when beyond the reach of the Sunday-school's ameliorating influence, they were still victims. Raikes died at Gloucester on April 5, 1811, and his statue commands a position on the Thames Embankment. His native city had not, up to a few years ago, at all events, sufficiently appreciated the lustre he shed upon it to erect a monument to his memory. The model was ceremoniously unveiled, but the actual sculpture was left still to seek.

BARON DE REUTER
Who Gave the World a Press View of Itself

Paul Julius, Baron de Reuter, the founder of the first telegraphic agency for collecting the news from all lands, was born at Cassel, in Germany, on July 21, 1821. At an early age he began a business life in a bank in Göttingen, but became quickly interested in telegraphy, and saw in it an opportunity for making his mark in an unoccupied field of enterprise. The telegraph systems of Germany and France had been brought near to each other but not united, in 1849, the German system ending at Aix-la-Chapelle, and the French system at Verviers. Reuter conceived the idea of forming a private link between the two systems, and did so by a service of carrier-pigeons, his wife operating one end of the line, and he the other. From this simple beginning sprang a scheme of communication that included the whole civilised and semi-civilised worlds.

Finding himself hampered by Continental restrictions, Reuter came to England in 1851 and took out letters of naturalisation. His initial experiments here were in organising telegraphic business and private messages between England and the Continent, and it was not till 1858 that he induced the newspapers to use his agency extensively. Then the "Times" accepted from Reuter's Paris office an extended report of a speech made by the Third Napoleon. Thus encouraged, Reuter aimed at giving his agency a world-wide range, and he magnificently succeeded. His work involved the laying down of special cables in some instances, as, for example, between Cork and Crookhouse, so as to quicken the receipt of news from the American States during the Civil War, before any cable was laid under the Atlantic.

Reuter turned his business into a limited liability company in 1865. In 1871 he was made a baron of Saxe-Coburg and Gotha, and by special grant the dignity was recognised in this country, and carried with it the customary privileges of the rank. The operations of the agency in the East brought Baron de Reuter into close association with Persia, and he was awarded special concessions by the Shah, which, however, he did not utilise. Baron de Reuter died at Nice on February 25, 1899, leaving a name that was better known perhaps, as a name, than any other in the world, although to most people who saw it continually in the newspapers it was a name of mystery.

No more complete example of an international monopoly could be named than Reuter's Agency, but as its work involved an enormous saving for such of the newspapers as must have all the up-to-date news, and as it was conducted with businesslike fairness, the evils of a monopoly did not show themselves. The network of correspondents serving Reuter covered all lands far more completely than was possible to the organisation of any single newspaper, or even any government service. Indeed, it is quite a common thing for Reuter's service to gather and transmit important news far in front, in point of time, of the observation of the same events by the official representatives of the British nation.

Everyone with knowledge admits that the supreme wonder of the twentieth century is the hourly collection of the news of the whole world through its Press; but by far the largest part of that credit is due to Baron de Reuter, who not only laid the foundations, but reared the superstructure of the system, and newspapers take part in the inheritance he has left by the simple process of paying an annual subscription. It was Reuter who gave the Press eyes that see everything to the ends of the earth.

THOROLD ROGERS
Who Gathered the Materials of the People's Story

James Thorold Rogers, who brought together the materials for making history the story of the progress of mankind rather than a record of the doings of kings, was born at West Meon, Hampshire, in 1823. He was educated at King's College, London, and Magdalen Hall, Oxford, where he took a First in 1846. Afterwards he remained as a High Church curate in the city. Later he undertook clerical and theological tuition, but after a time his position in the Church became exceedingly irksome, and he was the most active promoter of the Clerical Disabilities Bill, and the first, after its passing, to surrender his position as a clergyman.

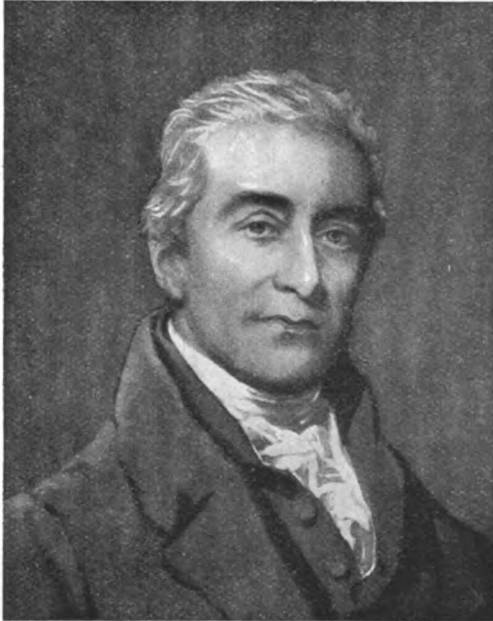
In 1859 Rogers was appointed Professor of Economic Science at King's College, London, a post he held for more than thirty years. His experiences at Oxford were more varied. Elected as the Drummond Professor of Political Economy, in 1862, he filled the position for five years, and then was cast out by a large majority because his views were too advanced for Oxford to bear, and expressed with too great freedom. Twenty-one years later Oxford repented, and Rogers was reappointed to his former professorship, which he held until his death. In the period between his rejection and reacceptance by Oxford he had twice served in Parliament—for Southwark between 1880 and 1885, and for Bermondsey in 1885-6. And he had also published six volumes of his monumental "History of Agriculture and Prices in England," a work that will ever give him a place among the pioneers of knowledge. Thorold Rogers died at Oxford on October 12, 1890.

The aim of Rogers in his master-book—the materials of which are used also in his "Six Centuries of Work and Wages"—was to show how the general mass of the people lived in the past in England, what they earned, and what the wage would buy. The book was planned to fill eight volumes, and the six published in Rogers's lifetime came out at intervals during twenty-one years. The materials for the two unfinished volumes had also been collected. The periods successively covered by these great books of information were 1259 to 1400 in the first two volumes, published in 1866; 1401 to 1582 in vols. II. and III., in 1882; and 1583 to 1702, published in 1887. For his facts, Rogers went carefully to original sources, and committed himself to enormous labours. The result is the provision of a great historical storehouse that has not its like in any other European country. Its value is cordially acknowledged by the many who were offended by the aggressive militancy of the author's opinions on the politics of his own day. There is no doubt that the labours of this dogged worker gave a new start to the writing of popular history, social and industrial questions taking the place of the high game of diplomatic politics which plays such a large part in most historical works, but means so little to the millions of mankind. How did the people eat, drink, work, play, clothe, and house themselves in successive periods? These were the

inquiries that mattered most in the eyes of Thorold Rogers, and he gave us the means of answering such questions.

In appearance Rogers was everything that one would expect a University don not to be—a big, loose-limbed, shaggy man, like a typical sheep-farmer from a moorland region, and he dressed and talked to suit that character, with a rough, unrestrained humour, and an air of revelling in a fireside "crack." But this familiarity concealed enormous industry, while revealing a shrewd and indomitably courageous mind.

SIR SAMUEL ROMILLY
The Great Opponent of Brutal Law

Sir Samuel Romilly, the distinguished lawyer who became an untiring advocate of reforms in the English laws which indis-

SIR SAMUEL ROMILLY

criminately demanded death penalties, was born in Soho, London, on March 1, 1757. His father, a watchmaker and jeweller, was of respectable Huguenot descent. The boy, who received an excellent education, was cursed in early youth by morbid imaginings of the servant who had charge of him, and the frame of mind so induced was further stimulated by much reading about crime. As a consequence, he suffered through life from occasional fits of gloomy reserve. After assisting his father for a short time, young Romilly entered the office of one of the Chancery clerks, and was able eventually to qualify for the Bar, and in 1783, join the Midland Circuit.

Romilly, who had a command of both French and Italian, visited France in close sympathy with the democratic upheaval there, and made the acquaintance of Diderot and Mirabeau, becoming an intimate friend of the latter. Through Italian he read Beccaria, and probably received from him the impetus towards his life's work—the reform of harsh laws. In 1784 he had already begun to write on constitutional law, and the publication of a book advising an increase of capital punishment drew from him an instant reply. By 1786 he was in the thick of a fight against the gross anomalies of criminal law, in which he never wavered.

By Mirabeau Romilly was introduced to Lord Lansdowne and the Whig chiefs, who were not slow to recognise his great abilities. In 1806, on the nomination of Fox, he was offered the post of Solicitor-General, although he had not previously sat in the House of Commons. He accepted the office, was knighted, and entered Parliament as member for Queensborough. He accompanied the Whigs out of office when they resigned in 1807, but was returned successively for the boroughs of Horsham, Wareham, and Arundel.

Shocked by the savagery and indiscrimination of the criminal laws, Romilly seized every opportunity, both in and out of Parliament, to condemn the existing penalties. There were at that time nearly 200 offences on the Statute Book punishable by death. Stealing shop goods to the value of five shillings, robbing a rabbit-warren, or cutting down a tree—each of these minor crimes equally with murder, was liable to be followed by the death penalty. As early as 1766, Goldsmith had made some acute criticisms on this senseless severity. "The Vicar of Wakefield" questions the validity of the right to hang a man except for murder; and adds, "When by indiscriminate penal laws the nation beholds the same punishment affixed to dissimilar degrees of guilt, the people are led to lose all sense of distinction in the crime, and this distinction is the bulwark of all morality."

Romilly was a friend and disciple of Jeremy Bentham, whose pamphlet, "The Hard Labour Bill," had considerable influence on contemporary humanitarians. Romilly was a frequent guest at Bentham's house, and was the mouthpiece of Bentham's opinions on this section of law. Not only was there no differentiation in the list of offences for which a man might be hanged, but the law was aggravated by being absurdly administered. People were really

hanged for only twenty-five of the offences on the list. Wholesale executions were inconceivable, and the result was that most of the folk condemned and solemnly sentenced at the Assizes were afterwards respited. Under such a system, instances of serious injustice arose, the fate of a convict depended on the whim of the judge, and the law itself lost every title to respect.

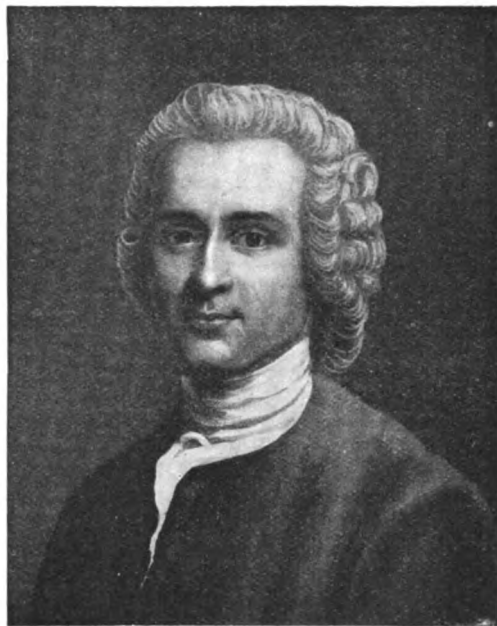
Romilly's mission was a noble one. Fired with generous instincts, he resolved to devote his best efforts to the task of getting these demoralising laws abolished. He published pamphlets, and spoke eloquently in Parliament. He succeeded, indeed, in getting an Elizabethan Statute repealed, which enacted the capital punishment for stealing from the person. But further reform was persistently blocked by Chief Justice Lord Ellenborough, and his followers in the Upper House. Though his Bills were thrown out Romilly's reputation was the admiration of all European philanthropists. In England, public appreciation was manifested by his return at the head of the poll for the City of Westminster, in 1818. A few months later his wife died in the Isle of Wight, and the poignancy of his loss so preyed on a mind too often subject to gloom that he committed suicide. He died on November 2, 1818.

Though Romilly did not live to see the full fruits of his labours, he laid the foundation of success reaped later by Mackintosh and others. His own actual successes were not insignificant.

Besides abolishing the death penalty for stealing from the person, he secured the repeal of the statute that made it a capital offence for soldiers or seamen to be found at large without passes; and he was the means of causing a Parliamentary Committee to be appointed which reported against transportation and the hulks. The movement he initiated has gone on until now only few crimes are punishable in England by death—namely, high treason, murder, piracy with violence, and destruction of public arsenals and dockyards.

Romilly was a man of fine presence, a powerful orator, and unquestionably the first advocate of his day, but inclined to taciturnity and an intense interior life seldom revealed to the public.

JEAN JACQUES ROUSSEAU
Who Wrought Revolutions with a Pen

Jean Jacques Rousseau, one of the most potent of the world's revolutionists through the use of a pen, and quite the strangest medley of a man who ever played the rôle of a prophet in the realms of sentiment, government, and education, was born in Geneva, on June 28, 1712, of a French refugee Protestant family. Rousseau is one of the few men who has told the world his own story with a frankness that in anyone else would seem like malice. His mother died when he was born; his father was a restless, dissolute, vapouring dancing-master, who, after feeding his weakly son's mind with wild romances, deserted him. For thirty-seven years Rousseau lived a life of failure, without securing a rag of character as a recommendation. In youth he failed first as apprentice to a notary, then as apprentice to an engraver. For twenty years, having run away at the age of sixteen,

JEAN JACQUES ROUSSEAU

he was a vagrant—sometimes a lackey, sometimes a secretary, sometimes a teacher of music, of which he knew little, or a copier of music; now a Catholic pervert, now a Protestant deist, but always immoral, following his own whims, and never taking on himself the duties of manhood. The five children of the rough servant girl who followed him through the greater part of his life, and with whom he eventually went through a marriage ceremony, were all left to public charity as foundlings, and lost sight of. At no time in his life did Rousseau do more than earn a bare living, and usually he was dependent on people whom he affected to despise, and towards

whom he felt no gratitude. Yet this weak, coarse, dissolute man, whose life was a monotonous record of dissatisfaction and petty feeling, who was uneducated, untrained in thinking, who wore out the patience of every friend, and at last, probably, ended by suicide a career of self-torture, was the literary mainspring of the French Revolution, strikes the keynote of the Constitution of the United States of America, holds a place in every work on the education of children, thrusts a word of argument into every discussion on the bases of public government, and has engraved on his tomb the words: "Here lies the man of nature and of truth."

Before suggesting how this came about, we must trace his life rather more in detail. The more reputable part begins in 1749, when he competed for a prize offered by the Academy of Dijon for the best essay answering the question: Has the restoration of the sciences contributed to purify or corrupt manners? He gained the prize. Three years afterwards the same academy offered another prize for the best answer to the question: What is the origin of inequality among men, and is it authorised by natural law? This time he did not gain the prize, but he arrested public attention and won such a place among the writers of the day as brought society buzzing around him, eager to know and patronise him. The argument with which he startled the worn-out artificial world of monarchical France, which knew it was all wrong, was that culture and citizenship are huge mistakes, property is a wrong, and government a tyranny, and happiness and virtue are found in pristine purity in savage life, or in a life of supreme simplicity nearest to Nature.

He was now offered a cottage in a forest by an admirer, and, practising his simplicity, lived there, or in another cottage close by, while he gave the world in three years three books on which his fame rests. These were a sentimental romance, "The New Héloïse," in letters after the manner of Richardson; the "Social Contract," an examination of the foundations of government; and "Emile," a biographical treatise on education, with views, by the way, on Governments and religion. These works, two of which were published in Amsterdam to escape the censor, offended all the authorities, but eventually captured the imagination of the French people. The immediate result was that the books were publicly burned and the arrest of the author was ordered, but Rousseau escaped to Switzerland. There, however, the Genevan Government arranged for his arrest should he enter his native city; and the Government of the Canton of Berne gave him fifteen days to leave its territory. Accordingly he passed into the principality of Neuchâtel, which then belonged to the King of Prussia, whose deputy was a sturdy refugee Scotchman named George Keith. Frederick the Great not only gave him shelter, but requested the governor to give him any necessaries he would accept. These Rousseau declined, with perhaps unnecessary preachings. "You wish to give me bread," he wrote. "Is there none of your own subjects in want of it? Take that sword away from my sight; it dazzles and pains me." Another letter of this time, to the Archbishop of Paris, who had denounced "Emile" in a pastoral, is one of Rousseau's finest writings. As Morley says, "At the very first words, the mitre, the crosier, and the ring fall into the dust."

Though Frederick would have Rousseau in his territories, Frederick's subjects would not, and, after three years' petty persecutions by the villagers, forced him to leave the Neuchâtel district and take refuge in an island on Lake Bienne in September, 1765. But the island was under the jurisdiction of Berne, and the Government once more moved him on. In December he arrived in Paris; and in January, 1766, David Hume, who was then secretary to the English Embassy, moved by the representations of his countryman George Keith, brought the homeless wanderer to England, and in March settled him at Wootton, near Ashbourne, in Derbyshire, in a house permanently lent him as a visitor of distinction.

While he was in England, Rousseau wrote his "Confessions" and his "Botanical Dictionary," and here he took a mental turn but little divided from madness. After staying eighteen months in Derbyshire, he slipped out of the country, obsessed by the idea that Hume, who had shown him every kindness, was his enemy. Indeed, during his remaining years, spent in different parts of France, where he was unmolested, he suffered from imaginary enemies and spies, and his only sane writings were those which tell of his Musings in Solitude, and were "the melodious expression in the music of prose of a darkened spirit which yet had imaginative visions of beatitude." Rousseau died suddenly on July 2, 1778, under circumstances that suggest suicide, though the doctor's certificate named apoplexy as the

cause. During the last few years of his life he was poorer than usual; and he had always been poor.

The influence of Rousseau's writing depended largely on the surroundings in the midst of which he wrote. The feeling was abroad that there was something very wrong with the world, and in whatever he wrote he began by clearing the ground of all existing institutions, traditions, methods. In his prize-seeking "Discourses" he simply swept away civilisation and all the sciences and made a new start, as if with the primitive man whom he imagined as the best of men. Was it Governments that he was considering—then he ruled out kings, aristocracies, and all existing powers, and based the State upon a social contract between each individual and the whole community. Each individual surrenders his will to the will of all in order that he may receive protection, and the whole community is pledged in return to defend him from injustice. The whole community is thus sovereign by the will of each member of the community, and kings or other governors have no powers but by popular assent. The sovereign people living in equal citizenship became the watchword of the Revolution that followed when Rousseau's influence had done its work. Was it education that he was dealing with—then he swept away the existing methods. The child is born good, was his cry; beware how you contaminate it by a false education. Till the age of twelve he would not let the child know what a book is. He would exercise the body, the senses, the perceptive powers, but in the simplest way while childhood is ripening naturally, sheltering it meantime from harmful experiences. The aim of early education must be to prepare for the complete living that comes later. The education must be an education by things through the senses, and not an education of words which to the child means little or nothing. The child should have the chance of acting for itself, thinking for itself, and not be directed, but only unobtrusively guided. In all this was much good sense—with some exaggeration—but far wiser than the rule-of-thumb methods that Rousseau sought to sweep away. He based education on a study of the child.

But in all his writing Rousseau, the contemner of words, was chiefly a word-spinner. His knowledge of life was limited. His theories were all sudden thoughts, which he built up by wordy defences. The State he imagines is not a real State; the child he teaches is not a real child living its necessary life, any more than his "noble savage" was a real savage. The systems he builds up are, as Morley conclusively argues, but expansions of his own phrases, "logical deductions from his own verbal definitions, wholly meaningless in connection with real human nature and the visible working of human affairs."

But Rousseau caused people to pause by his bold contradictions and paradoxes; he did so by virtue alike of the freshness of his thought and the charm of its expression. Untrained as a writer till he reached middle age, he had "the gift of the golden mouth," and he was the first genuine man of the people to interpret the dumb masses. "It was in Rousseau that polite Europe first hearkened to strange voices and faint reverberations from out of the vague and cavernous shadow in which the common people move."

LORD SHAFTESBURY

Saviour of the Children and Civiliser of England

Anthony Ashley Cooper, seventh Earl of Shaftesbury, was born in London on April 28, 1801, educated at Harrow and Oxford, and sat in the House of Commons for practically a quarter of a century before succeeding his father in the peerage. His name and record are inalienably associated with most of the great social reforms of the nineteenth century, and particularly with all the factory legislation of the period. At the outset it is to be noted that, salutary as were many of his achievements, he was a man of curiously unequal mind. He hated the Reform Act, yet himself compassed reforms infinitely more drastic than those provided by that measure. He feared to trust the democracy of his own country with the ballot, yet toiled to win unqualified emancipation for the slaves, and to secure civil and political liberty for the Poles. He was the friend of all Jews save those who desired the abolition of the cruel disabilities by which their lives in England were embittered. He sought to evangelise the world, yet bitterly denounced exponents of any religious tenets but his own; voted against the appointment of Temple as Bishop of London; and characterised "Ecce Homo" as "the most pestilential volume ever vomited, I think, from the jaws of hell." There is sometimes but a step between noble zeal and a condition bordering on fanaticism, and occasionally Lord Shaftesbury's ardour for the right impelled him to equally vehement advocacy of intolerance.

But in the social regeneration of England his uncompromising hatred of wrong and injustice was perhaps, on the whole, the greatest driving force for good in his age. Other men felt as strongly, but he had the unique advantage of appealing as a patrician on behalf of the humblest, the least articulate of the nation. He was a benevolent Dives voicing the woes of the children of Lazarus. It was a new and startling rôle for a scion of a noble house. Even his family did not clearly understand his purpose. When, at fifty years of age, he succeeded his father, he was generally recognised as one of the great Christian leaders of his generation. Yet his sister gravely said to him: "Now that you have come into the title you must learn to swear; your father always did, and gained great respect by it in the country." It was by bestowals of blessings upon humanity rather than by curses flung at the heads of rustic neighbours and dependents that he preferred to deserve immortality.

The historian of the Victorian era must never disregard the life of Lord Shaftesbury if he would rightly depict the age. Written as an ordinary chronicle of the times, the story might seem the sour concoction of a Poe turned annalist, or of some malignant partisan determined brutally to caricature the age through which his father lived. But every Bill proposed, or Act passed, at the instance of Shaftesbury, constitutes an indictment of nineteenth-century England more damning than any that her bitterest foe could draw. He had to attack a system unique in utter wanton savagery, a system touching the lives of old and young, of the afflicted and the normal.

A typical example was to be found in the lot of the insane, on whose behalf Shaftesbury toiled for nearly sixty years. When he began his crusade these helpless wretches were treated as entertaining wild beasts, "chained together on beds of straw, naked, handcuffed, and shown at twopence a head for each visitor." The actually insane were few; those in danger of being driven insane were multitudinous. The bulk of the nation were the victims of conditions which the "Times," writing at the death of Shaftesbury, upon his factory legislation, described as follows: "Slavery in the West Indies had nothing worse in comparison to show with it. In the manufacturing districts wages were at a starvation rate, and the children were literally worked to death—murdered by inches . . . There were everywhere a dreadful reality of oppression, and a fearful sense of injustice, of intolerable misery and of intolerable wrongs, more formidable than any causes which ever led a people to insurrection."

The factory legislation which he succeeded in passing left the circumstances of the workers far from perfect, but at least it was no longer possible to say, as in the days of his fighting he and a Royal Commission had to report, that in many of the great manufacturing towns children under seven, and sometimes under six years of age, worked fourteen, fifteen, and sixteen hours a day; that they were beaten with sticks and straps and rollers, or immersed in cold water to keep them awake; that they had no interval for breakfast or tea; that the crippled and distorted might be numbered by hundreds, perhaps thousands, in a single city; that little children in cotton-mills, in tending the machinery, had to walk from twenty to thirty miles a day. In factory districts as many persons died under the age of twenty as under forty in any other part of the country; in Manchester half the population died under the age of three years. Against opposition which makes us blush today for men such as the Lord Althorp of the day, Peel, and Bright, Shaftesbury worked on to victory and the Factory Acts.

He went everywhere and saw everything—into mills and factories, down the mines, into the awful homes of the people. The conditions in mining districts seem incredible today, but the legislation enacted resulted from the evidence of a Royal Commission, and is beyond challenge. That evidence showed that children were consigned by their parents practically from the cradle to the coal-pit, to perpetual labour ending only in incurable disease and death. Women toiled like beasts of burden, half naked, in noisome mines, surrounded by an atmosphere of indescribable vice and corruption. They were harnessed—the women and the children—with chains, like animals, to trucks, and pursued their labour under the most galling and painful conditions, frequently for eighteen hours a day—hauling, pumping water from flooded pits, women carrying half-hundredweight loads of coal up ladders which, in the aggregate, equalled the height of St. Paul's Cathedral.

"In the West Riding of Yorkshire," the reformer told Parliament, "it is not uncommon for infants of even five years to be sent to the pit. About Halifax and the neighbourhood children are sometimes brought to the pits at the age of six years,

and are taken out of their beds at four o'clock. Near Oldham children are worked as low as four years, and in the small collieries towards the hills some are so young that they are brought to work in their bedgowns." It was in 1840 that he took up this crying scandal, with its wholesale legalised murder of women and children, its widespread dissemination of disease, and every circumstance of "coarse and loathsome exposure to which savage life hardly afforded a parallel." And yet, in spite of this evidence of frightful immorality and bestiality and of the deaths of mothers and their children, the coal-owners declared

LORD SHAFTESBURY

The painting by G. F. Watts, R.A., photographed by E. Walker

that with a modification of the conditions they could not work their mines at a profit, and practically with one voice cried: "Hands off the mines!" Pease, of Darlington, had said much the same thing of the Factory Act: "If the hours of labour were abridged, he must, unless he submitted to torture and overdrive the children, inevitably close his manufactory!"

Another beneficent Act secured by Lord Shaftesbury was that which abolished chimney-sweeping by boys. Children of from four to eight years were sold by their parents to men who employed them to force their way up chimneys and clear away the soot. Beginning the day's work at three or four in the morning, they would often be half choked in the flues, and, fainting, would die where they were wedged, unless the fire of straw lighted below as a restorative or alarum brought them to their senses. If they escaped death in this way, they ended their unhappy days, as a rule, from the effects of a terrible malady—chimney-sweeper's cancer. Here, again, Lord Shaftesbury met fierce opposition. If these little valueless lives were to be spared, an Englishman's house was no longer his castle; he must actually alter his chimneys, or arrange to have them mechanically swept!

If he had done nothing but introduce justice and mercy into factories and mines, Lord Shaftesbury's memory would deserve imperishable renown. But a host of other reforms are associated with his name. They are part of the history of the nineteenth century, and must be sought in detail elsewhere. He was not unaided in his noble work of reform, but he was the one strong man in Parliament who feared neither Cabinets nor caucuses. He got his information first-hand from personal investigation, and made the world ring with his story of the wrongs and villainies perpetrated, in the name of British industry, at the cost of the poor, the weak, and the lowly. With all his little prejudices and eccentricities as to certain causes and classes, Lord Shaftesbury was clearly one of the noblest-hearted men of the age which he redeemed from the grossest of its barbarities. He died, universally mourned, at Folkestone, on October 1, 1885.

THOMAS TELFORD

The Herd-Boy who Became the Master Road-maker

Thomas Telford, one of the greatest of British engineers, was born, the son of a humble shepherd, at Westerkirk, Langholm, in the Eskdale district of Dumfriesshire, on August 9, 1757, and, left fatherless at an early age, was engaged as herd-boy until his fifteenth year. Then, having had a little schooling, he was apprenticed to a stonemason, and, while plying mallet and chisel, was fashioning his mind on the poems of Burns and Milton, lent him from the small library of a lady who became interested in "Laughing Tam," as the cheerful son of poverty was known. He was still a journeyman mason, earning nine shillings a week, when he blossomed out as a poet, and found himself in print in an Edinburgh magazine. Two profitable years of experience in Edinburgh at his calling

paved the way to London, where he worked on the new Somerset House, passing thence to Portsmouth, to gain his first considerable position as superintendent of a house which was being built for the dockyard commissioner. Here he had a valuable insight into dockyard methods and requirements, and then passed on to Shrewsbury, just in time to gain the post of surveyor of public works for Shropshire, a position in which he so well justified himself that he was next appointed engineer and architect of the Ellesmere Canal, by means of which he was to connect the Mersey, the Dee, and the Severn. This was an undertaking far transcending those of Brindley, and in some respects it was another Brindley who was to see the thing through.

Telford had learned nothing but the three R's at school; he had had no engineering training; he had no capital with which to engage expert advisers. The plans had to be evolved in his own brain and to find expression in iron and masonry in forms such as the world had not before seen. The aqueducts over the valley of the Ceiriog at Chirk and over the Dee at Pont-Cysylltau show how he rose to the challenge. Brindley's wonderful pioneer work along the same lines did not help him; he had to better the Brindley scheme, and to do so meant providing entirely new means. The efforts of pioneers must always be eclipsed by those of their successors, and it in no wise detracts from the magnificent work of Brindley to say that Telford's aqueducts were infinitely better. The water was carried across, and the barges upon the water, in huge troughs of iron supported upon lofty columns of masonry; Brindley's had beds of puddle-clay. The Chirk aqueduct bore the canal across a distance of 700 feet of river and valley, 70 feet up in the air, while the aqueduct over the Dee, which was 121 feet above low water, was nearly twelve feet in width and over a thousand feet in length. The work was so revolutionary in character, yet so successful, that on its completion the young engineer was practically commissioned to build a new London Bridge, and was deterred only by technical difficulties about the necessary approaches—difficulties which engineers of our own days find at times almost insuperable. Many other fine works were carried out by Telford at this time in the West Country, and then he was called to a national work in Scotland.

He had to build the Caledonian Canal, which bisects Scotland, so that a ship entering the Moray Firth on the eastern coast proceeds to Ireland by way of Loch Linnhe on the west coast. The work cost a million pounds and took eighteen years to complete. The canal has twenty-eight locks, and rises at the southern end ninety feet in eight miles, a climb effected by eight mighty locks, which Telford picturesquely described as Neptune's staircase. In the end the canal did not attract the traffic that had been expected, and was on that account a disappointment to its builder. But the canal itself was really of less account to Scotland than the incidental work attending it. Telford did for Scotland during this time that which we are now doing for Africa; he gave it highways and bridges, harbours and habitations. Scotland had few roads other than those which had been constructed for military purposes; that peace required her highways no one had dreamed. Hence there were few proper roads; hamlet was isolated from hamlet; such roads as did exist were in the main without bridges, and, as to many of them, ran along the coast, to be submerged by every tide. Telford not only cut a way through the land from sea to sea, but opened up the heart of the land by a network of fine new roads, while he spanned old roads with bridges and built harbours and wharfs for shipping. Over a thousand miles of roads, with some six-score bridges, besides churches, manses, harbours, and fishery stations were added to the possessions of the land of his birth.

The outward and visible evidences of civilisation followed in his train. Well might he boast that he had advanced the country by a hundred years. Where before women had toiled with packs of merchandise on their backs, the way was open to wheeled vehicles; where the crooked bough of a tree had been dragged by hand as plough, the modern implement of agriculture was introduced. But a still more potent influence diffused from the actual works with which he was immediately associated. Telford had to train his own men, to teach them to make tools and to handle them. Over three thousand men at a time were under his watchful care, and he was able to say, "These undertakings may be regarded in the light of a working academy, from which eight hundred men have annually gone forth improved workmen." No richer gift was ever bestowed upon Scottish industry, for, as has been repeatedly shown in this work, the crying need of Scotland was for skilled craftsmen.

Telford's next great work was the building of the noble highway from London to Holyhead. It remains a noble highway to this day, and is more appreciated, now that the motor-car has restored public roads to their ancient use, than it was for two generations after its construction. The road ends, or did end, on the coast of Carnarvon; Telford made it leap the Menai Strait by means of a magnificent bridge.

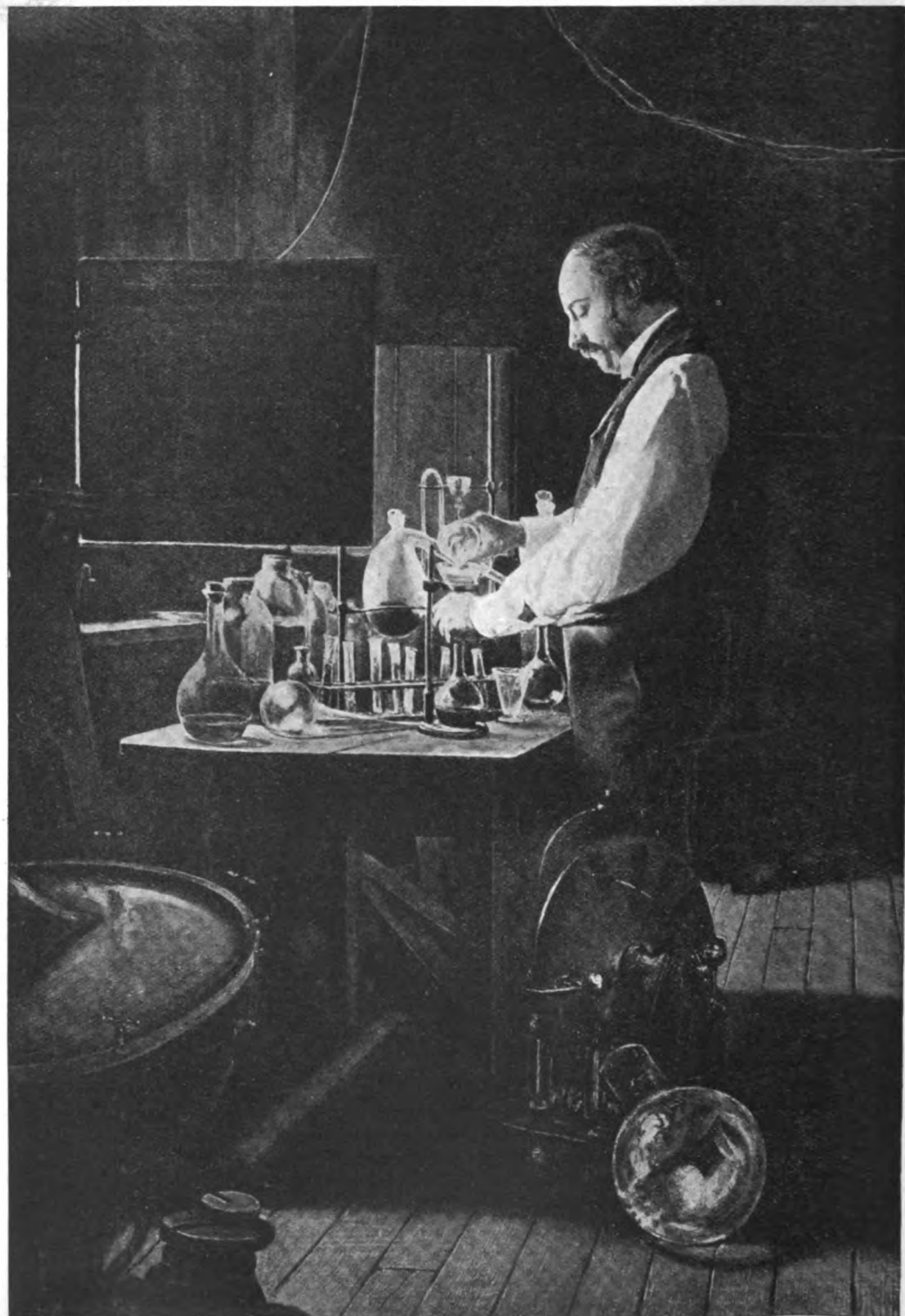
Until then the treacherous sea passage, with an occasional rise in tide of 30 feet, had to be made in frail ferry-boats. Telford's bridge, 1710 feet long and 100 feet above high tide, carries the road across the sea, on to Anglesey, and then on to Holyhead Island, where the seaway to Ireland is open. The bridge, begun in August, 1819, was completed in April, 1825. Telford was himself in attendance, and when friends called afterwards to congratulate him upon his success, they found him on his knees in prayer. After this Telford carried out many fine canal schemes. There was much talk of steam railways at the time. When the line between Manchester and Liverpool was projected, he refused an offer of £1000 a year, because he feared that railways would be inimical to the interests of the men for whom he had built canals.

Rennie put the refusal on other grounds. Telford, he says, did not believe that steam railways had a future. His Birmingham Canal, as a matter of fact, was constructed in opposition to a scheme for a railway, and Rennie says that Telford laughed heartily when he succeeded in linking Birmingham to Liverpool by waterway in place of the steel road which had been suggested. "The fact is that Telford having been bred in the old school, and having seen the triumph of canals, could not, or would not, believe in the efficacy of railways, or that they would ever succeed." Naturally he did not wish to see his noble work on the Holyhead road superseded. Smiles holds, however, that Telford had conscientious scruples against accepting a fee for work done in opposition to the canals.

Such a thing would be characteristic of the man. Telford cared nothing for pecuniary reward. The bulk of the magnificent work carried out by him in Scotland under the British Fisheries Society was done gratuitously, and his professional fees were so low that a deputation of engineers once attended to expostulate with him. He was as generous in his gifts as he was modest in his demands, and, in addition to establishing free libraries in the neighbourhood of his old home, he helped the poorer inhabitants every winter with gifts of money. Throughout his life he was of a gay and happy disposition, and when the hostel at which he lived in London changed hands, such was his popularity that, when he proposed to leave, the new proprietor said, "What, leave the house? Why, sir, I have just paid £750 for you!" Among his many friends were the chief poets of the day. Southey and Campbell, who loved him for his splendid personal qualities, were both benefited at his death by legacies. It was Southey who aptly named him the "Colossus of Roads."

Telford's reputation extended to the Continent, where he built the Gotha Canal,

THOMAS TELFORD

linking the Baltic with the North Sea. Many fine monuments remain to attest his skill and industry, such as the harbours of Wick, Dundee, Peterhead, Banff, Fraserburgh, Fortrose, Cullen, Kirkwall, and Aberdeen; and such bridges as the Conway, the Broomielaw in Glasgow, and the Dean in Edinburgh; and, as to canals, the Macclesfield, the Birmingham and Liverpool Junction, the Gloucester and Berkley, the Weaver system, and the great tunnel of $1\frac{3}{4}$ miles on the Trent and Mersey scheme. Telford, who was actively at work until past seventy—the St. Katherine's Docks, London, being his last big scheme—died in London on September 2, 1834, and was buried in Westminster Abbey.

LORD RAYLEIGH AT WORK IN HIS LABORATORY, AS PAINTED BY MR. PHILIP BURNE-JONES

From a photograph by Mr Frederick Hollyer.

CONTINUED FROM PAGE 4837

CHEMISTS & PHYSICISTS

LORD RAYLEIGH

The Most Exact Experimenter of the Age

Lord Rayleigh is a man of the calibre of Lord Kelvin. He has probably the widest outlook on science of any living man. He has worked in all branches of physical research, and touched few subjects that he did not advance. Moreover, he is a fine representative of a class of workers which is the especial glory of our country. In other lands the advancement of science is undertaken almost entirely by professional men working at a salary in universities and other centres of learning, or studying and striving for professorships.

But the greatest of our modern men of science, Darwin, was a country gentleman, labouring simply for the love of truth, and using his wealth and leisure for the benefit of the human race. The Strutt family, to which Lord Rayleigh belongs, is as remarkable as the Darwins for its passion for scientific research. Both his brother and his son have followed the same path in life as Lord Rayleigh.

Born in Essex on November 12, 1842, the famous physicist entered Trinity College, Cambridge, in 1861, and there gained the distinction of being the only peer to become Senior Wrangler. A mathematician of genius, he took up the study of optics, and showed that the blue colour of the sky is due to the shorter waves of light being scattered by the fine particles suspended in the air. He considerably extended our knowledge of optical instruments, proving that under certain conditions little advantage was gained in using a lens, and that a telescope could be made simply of an aperture with an eye behind it. By his experiments on this subject he did much to popularise pinhole photography. Indeed, by working out the problem of stopping or shutting down the lens he improved photographic art generally. His great work on the theory of sound was completed in 1878. It is one of the classics of modern physics and mathematics. Recently Lord Rayleigh has been attracted by the mathematical problems of mechanical flight, and has contributed some important papers on the matter.

His most popular achievement was the result of a piece of laborious revision of some of the simpler studies in chemistry. About 1882 he decided that it would be well if the densities of the principal gases were re-determined. The job was apparently just one of those unexciting pieces of laborious, useful research that would only affect the figures given in the dullest part of textbooks. Lord Rayleigh began by going over the work of the men who had studied the gases of the atmosphere. Nothing of note occurred until he came to the study of nitrogen. This element he obtained in two different ways—he extracted nitrogen from the air, and he also prepared it from ammonia. He found that the ammonia nitrogen was about 1-200th less weighty than the atmospheric nitrogen. Naturally, he thought at first there was some error in his methods of experiment. Most men of science would have regarded the slight difference as an allowable margin of error in the production of nitrogen from different sources.

But Lord Rayleigh had set out with the aim of arriving at more exact results than his predecessors. He repeated his experiments, until he was absolutely certain that he was not responsible for the 1-200th difference in the weights. In his private laboratory at Terling, in Essex, his instru-

ments were often of the crudest kind—appliances made by himself from sealing-wax and anything that was handy. But the exquisite care and the foresight with which the researches were conducted and repeated in different ways convinced him that there was something unknown in ordinary air that mingled with atmospheric nitrogen and added to its weight.

So he set out to discover this unknown element, and Sir William Ramsay volunteered to undertake some of the experiments. The two researchers checked and controlled each other by adopting different methods. Lord Rayleigh used the electric discharge, while Sir William Ramsay passed the atmospheric nitrogen over heated magnesia. The results agreed; and in a joint memoir the two men announced that they had discovered a new element in ordinary air, to which they gave the name of argon. Lord Rayleigh also pointed out that even the presence of argon did not account for the difference in weight between atmospheric nitrogen and pure nitrogen. So Sir William Ramsay worked on this fresh problem, and discovered new elements.

Lord Rayleigh, in response to a memorial presented to him, acted for some years as the successor to Clerk Maxwell at the Cavendish Laboratory. He has also worked for the Board of Trade in devising methods of gas-testing and electrical measurements, and he has helped the War Office in investigating the scientific aspect of big guns and other explosive weapons.

RENE ANTOINE DE RÉAUMUR

The Inventor of a Thermometer

René Antoine Ferchault de Réaumur, one of the most versatile of the older school of men of science, was born at La Rochelle, on the Bay of Biscay, on February 28, 1683. The son of a judge, he took up at first the study of law, but, acquiring a livelier interest in science, he went to Paris at twenty, and there astonished the learned world by his genius in mathematics. In 1708 he was made a member of the Academy of Sciences, and for the rest of his life he was absorbed in the pursuit of various kinds of knowledge.

As he possessed a splendid fortune, he was master of his career, but, unlike many men of wealth, he scorned delights and lived laborious days, making a noble use of his opportunities. He is best known by the thermometer named after him. In point of date his invention comes between that of Fahrenheit, of Dantzig, and that of Celsius, of Upsala. He used spirit instead of mercury in his instrument for measuring heat, and fixed his freezing-point at 0 and his boiling-point at 80. It is certainly more convenient, especially in scientific calculations, to take zero as the freezing-point, and Réaumur deserves credit for first doing this. But since the decimal system of measurement has come largely into general use on the Continent, and widely into scientific use in our country, Celsius's later improvement of dividing the space between freezing-point and boiling-point into a hundred parts has tended to antiquate Réaumur's instrument. The Frenchman's thermometer is now only used in Germany and Russia. In England we keep to the earlier invention of the German Fahrenheit, while France uses the Swedish invention of Celsius.

But his thermometer is not Réaumur's only title to fame. He made important discoveries in physics, natural history, and the industrial arts. Reaumur died on October 17, 1757.

WILHELM KONRAD RÖNTGEN

How Photography Led to a Great Discovery

In the ordinary course of events, Wilhelm Konrad Röntgen would still be a hard-working German professor, doing useful work on the problems of elasticity and the specific heat of gases. His fame is largely due to the fact that he is a man with two useful hobbies—glass-blowing and photography. Born at Lennep, in Prussia, on March 27, 1845, he studied at Zurich under Kundt, and, becoming assistant to his master, followed him to Würzburg in 1870. After a successful career in other German towns he returned in 1888 to Würzburg as professor of physics. After Hertz and Lenard had found that the visible ray produced by an electric discharge in a vacuum glass tube could pass through a thin sheet of metal, Röntgen, like many other men of science, began to experiment in the same direction. Having studied glass-blowing, he was able to save expense, and also to amuse himself, by blowing glass tubes of curious shape, and using his own powerful lungs to empty them of most of the air they contained. By then employing the ordinary means of making a vacuum, he obtained a more rarefied condition in his tubes than ordinary experimenters did.

In 1892 he made a vacuum glass globe, with S-shaped tubes at either end. He rightly regarded the visible rays as electrified particles, and he wanted to see if, when they traversed the bends of the tube, any signs of friction would be visible. The

experiment was without any apparent result. He made it on a desk heaped up with books, glass tubes, and photographic material. A large book he had just been reading rested on a photographic plate, and in the book was a key that he often used as a bookmark. On returning from lunch, he took up the photographic plate in the ordinary way, and employed it in photographing an outdoor scene. When he developed the negative, the shadowy outlines of a key were clearly visible on the plate. He asked all his students if they had been doing anything with his photographic material, and, on being assured that no one had touched the plate, he resolved to get to the bottom of the mystery. The next morning he arranged the things on his desk in as exactly the same position as he could remember. He sent an electric charge through his new tube, and developed the plate beneath the book, and found the picture of the key again on the negative.

Greatly interested, he experimented with other objects, and found that the strange, invisible ray from the glowing tube would penetrate other things besides the leaves of a book, but he could not for some months find any way of making the mysterious ray visible. Suddenly it struck him that, as the glass of the tube became fluorescent when an electrical discharge was sent through it, other substances might be made to glow by the unseen ray.

He put aside all other researches, and, excluding all visitors from his laboratory, he set to work with his research students to test the fifty substances of a fluorescent nature. He found that barium platinocyanide gave the brightest glow when the strange ray struck it. When a screen coated with these crystals was placed behind a black cardboard, the invisible ray became visible by the glow it made. So—two years after his first chance discovery—Röntgen was able in December, 1895, to announce to the scientific world the existence of the X-ray. Being unable to ascertain the character of the ray, he called it by the symbol X that is generally used in science to denote an unknown quantity. The crowning discovery of the nature of the the X-rays has recently been made. It is formed of electric waves, extremely small in length. At the present time Professor Röntgen holds the Chair of Physics at Munich University. He is one of the comparatively few scientific men who, when living, have made their names known in every civilised land.

ERNEST RUTHERFORD

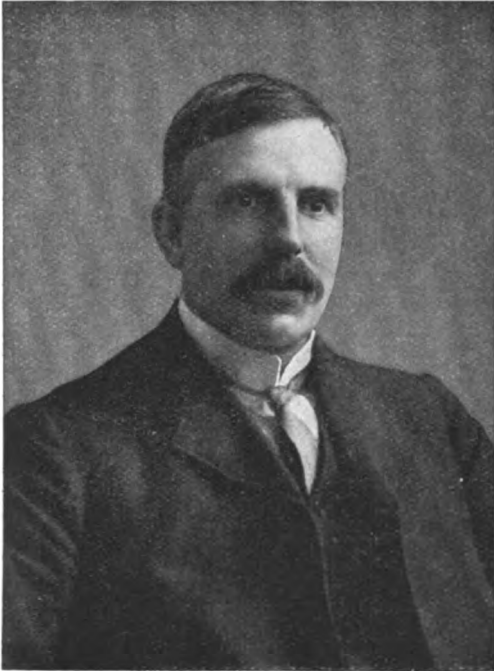
A Brilliant Student of Radio-Activity

Professor Ernest Rutherford, the discoverer of the transmutation of the elements, was born at Nelson, in New Zealand, on August 30, 1871. His brilliant career is a striking example of the value of scientific scholarships in helping able students to acquire and master the increasingly expensive instruments of modern research. Excellent work may no doubt still be done in various fields of science by men possessing very simple instruments, but in the study of radio-activity, in which Rutherford has distinguished himself, both money and influence are necessary simply to obtain a minute quantity of radium salts on which to experiment. Professor Rutherford studied at Canterbury College, in New Zealand, and in 1894 won a scholarship that enabled him to come to England and work under Sir J. J. Thomson, at the great Cavendish Laboratory, in Cambridge.

The young New Zealander had taken up in his native country the study of electric waves. He continued to work on the subject at Cambridge, and invented a new form of detector, which enabled him to send wireless telegraphic messages over a distance of half a mile. This he accomplished some time before Marconi succeeded in a similar feat. Rutherford also made a series of important researches at the Cavendish Laboratory on the motions of electrified atoms, on ultra-violet light, and on the mysterious rays emitted by uranium salts. The discovery of the uranium ray by Becquerel was the starting-point in the development of the wonderful science of radio-activity. Becquerel himself misinterpreted his great discovery, and considered it merely a kind of fluorescence. Rutherford was one of the first men to show that the strange ray was not a form of light, but a new and important kind of force. So original was the work of the New Zealand student that in 1897 he was awarded the Coutts-Trotter studentship.

The next year Sir J. J. Thomson was consulted with regard to the choice of a Professor of Physics for McGill University, at Montreal. He pointed out that Rutherford, though quite a young man, had greatly distinguished himself by his originality, insight, and capacity for work. So in 1898 Rutherford was appointed professor at the Canadian university. At Montreal, Rutherford continued his researches into the problems of radio-activity; and one of his colleagues, Professor Owen, of the engin-

eering faculty, pointed out to him the peculiar inconstancy of the radiation of thorium, the rare earth used in making gas-mantles. Rutherford took the matter up, and in 1900 discovered the gaseous emanation of thorium, and showed that this emanation made other substances active. It seemed to him that the emanation was a gas, and a distinct form of matter. This meant that the element thorium was breaking up into a new element. It was the beginning of the discovery of the transmutation of matter.

At this point, a young Englishman, Mr. Frederick Soddy, came from Oxford to

ERNEST RUTHERFORD

McGill University as a chemical assistant, and worked under the direction of Professor Rutherford. Together they tried the effect of varying the physical conditions under which thorium produced its radiation; and in 1902 they ascertained that the emanation came from a substance which could be separated from thorium. They proved that radio-activity was an atomic phenomena in which new types of matter are produced. Their views were strongly contested, but they have prevailed, and form, indeed, the basis of the science of radio-activity.

Turning from thorium to the more powerful and complex radiations of radium, Professor Rutherford and his fellow-worker continued their magnificent course of discoveries. In particular, it struck them that one part of the radiation consisted of the light element helium, and this was confirmed by experiments afterwards conducted by Mr. Frederick Soddy and Sir William Ramsay. In 1907 Professor Rutherford returned to England as Langworthy Professor and Director of the Physical Laboratories at the University of Manchester, where he has now created a school of research second only in importance to the Cavendish Laboratory at Cambridge, directed by his old master, friend, and admirer, Sir J. J. Thomson.

CARL WILHELM SCHEELE

An Apothecary with a Genius for Experiment

Carl Wilhelm Scheele was born on December 9, 1742, at Stralsund, the capital of Pomerania, which at that time belonged to Sweden. At fourteen the boy was apprenticed to an apothecary at Gothenburg, and here he began his remarkable career in science. A few antiquated textbooks, and the ordinary apparatus of an eighteenth century apothecary, were all that he had to work on. With them, however, he trained himself to a dexterity in manipulation unequalled by any other living man. At thirty-two Scheele was still working for other apothecaries, lacking the capital to set up for himself. He thought himself very fortunate, in 1775, when some scientific friends obtained for him a pharmacy, in which he had to work until he had paid out the widow of his predecessor. He died in his forty-third year—on May 21, 1786—still only a drug-seller, killed by working in bitter winter weather in the outhouse that served him as a laboratory.

Yet this obscure apothecary, living a lonely life in the small town on the shore of a Swedish lake, hampered by poverty, harassed by debt, and sunk in melancholy, succeeded in changing the entire aspect of chemical science. Endowed with a wonderful gift of observation, Scheele carried out a long series of splendid researches with the most meagre of means. He was a pioneer in nearly every branch of his science. The pure joy in a discovery amply repaid him for the labour he spent upon it. Tackling, for instance, black oxide of manganese, that many able workers before him had vainly studied, he discovered, in rapid succession, four new substances—chlorine, oxygen, manganese, and baryta. He was ahead of Priestley in isolating oxygen, and his discovery of chlorine afterwards revolutionised the bleaching and dyeing industries.

Again, bringing his inventive genius to bear upon organic chemistry, which was then almost untouched, he worked out new methods in every direction for isolating the products of vegetable and animal bodies, and prepared a considerable number of acids and other organic compounds which had remained unknown. He laid the foundation of photography by showing that the effect of sunlight upon chloride of silver is to decompose it, and compel it to give up its chlorine. He also used silver chloride for analysing the spectrum of sunlight, and discovered that the violet rays had a stronger chemical action than the blue, yellow, and red rays.

Naturally a man could not make these discoveries without becoming famous. He was offered a well-paid position in Berlin, and some English nobleman, probably Lord Lansdowne, the friend of Priestley, offered to provide for him if he would come to England, but Scheele wanted neither money nor honours. He kept to his pharmacy, and pursued his experiments at the same time, and worked himself to death before reaching the prime of life.

FREDERICK SODDY

An Alchemist of the New School

Frederick Soddy, one of the most brilliant of our younger men of science, was born at Eastbourne on September 2, 1877. From a school in his native town he went to the University College of Wales, at Aberystwith, and proceeded to Merton College, Oxford. Here he devoted himself particularly to chemistry, winning first-class honours in 1898. At twenty-one he went out to Canada as Demonstrator in Chemistry at the McGill University, at Montreal. No one would then have thought that Montreal would quickly become the scene of the most revolutionary movement in the history of science. But another young man of science at McGill University, Professor Rutherford, had just discovered something extraordinary about thorium, one of the radio-active elements, and he communicated his discovery to Mr. Soddy, and they began their now famous partnership in research. They collected the emanation from thorium, and condensed it by means of liquid air, and found it was a distinct, new form of matter. They then tackled radium, and split its ray into a number of smaller rays, each with properties of its own, and they discovered reasons for supposing that one of those rays was a form of helium.

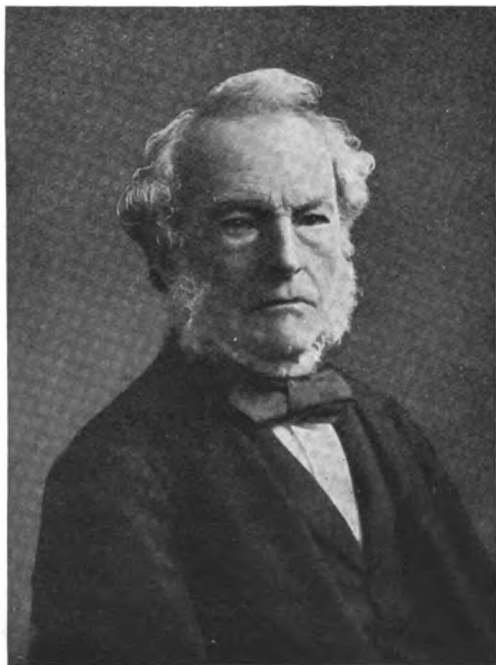
This theory Mr. Soddy helped to reduce to an actual, verifiable fact on returning to England and working with Sir William Ramsay at University College, London. After being appointed Lecturer in Physical Chemistry and Radio-Activity at Glasgow University, in 1904, Mr. Soddy undertook an interesting experiment to discover the parent element of radium. The experiment is not yet completed, for Mr. Soddy estimates that it takes many thousands of years for uranium to turn into lead, and radium is grown from it almost as slowly. But by 1912 he obtained from uranium an infinitesimal quantity of radium, and he was

FREDERICK SODDY

able to conclude that uranium is not the direct parent of radium, for radium has a life of only about 2500 years. None of our present supply of this extraordinary element, that costs £750,000 an ounce, was in existence when Socrates was living. The radium of his day has disappeared, partly in helium gas and partly in electrical energies. Our modern radium has been grown afresh from its parent element. A substance intermediate between uranium and radium has been found by Boltwood in America, but as even this intermediate substance has a life of 30,000 years, it does not seem to be the mother of radium. There are probably some still unknown

forms of matter, with a shorter life, from which radium is directly grown. On the search for them Mr. Soddy, like many other men of science, is now occupied.

SIR GEORGE GABRIEL STOKES
A Great Mathematician

Sir George Gabriel Stokes, one of the master-minds of the Cambridge School of Science, was the son of an Irish clergyman, and was born at Skreen, in Sligo, on August 13, 1819. Educated mainly by his father, who had been a scholar of Trinity College, Dublin, the boy displayed his originality of mind by making out new ways of doing

SIR GEORGE STOKES
Photograph by Elliott & Fry

sums better than those in his books. He owed much to the teaching of Francis Newman, the brother of the famous Cardinal, who was mathematical master at Bristol College, where Sir George went for two years. At sixteen Sir George became interested in natural history. One day, on a walk with a friend, he failed to return the salutation of some ladies of his acquaintance. He called upon them afterwards to apologise, and explained he had been unable to lift his hat because it was full of beetles!

In 1837 he went up to Cambridge, where he was to live for sixty-six years. His mathematical abilities attracted wide attention, and he graduated as Senior Wrangler and first Smith's Prizeman. In the same year he was elected Fellow of Pembroke College, and began to apply his remarkable powers of mind in original investigations. Many of the standard theorems in the study of moving fluids were invented by him. In 1849 Stokes had so distinguished himself that he was made Professor of Mathematics as Cambridge; and by reason not only of his genius, but of his uncommonly long life, he had a large and lasting influence in moulding the thoughts of the chief centre of scientific work in Britain.

His achievements are so numerous and spread over so wide a field that a mere catalogue of them would fill some pages. In optics he was the benefactor to the vast number of persons who suffer from astigmatism. for he invented the first convenient method of discovering this very common defect of vision. Perhaps his two great achievements are his discovery of fluorescence and his pioneer work in devising the means of studying the chemistry of the sun and the stars. As is well known, there are many waves of light which are so short that our eyes cannot perceive them. Stokes discovered that if these invisible rays were passed through a solution of sulphate of quinine they were lengthened and made visible. Improvements in photographic methods at first diminished the scientific utility of this curious property of fluorescent substances, but the fluorescent screen has again become a most valuable instrument in connection with the study and use of X-rays as well as of ultra-violet light and other invisible radiations.

In 1854 Stokes made his greatest discovery. By putting some salt in the flame of the spirit-lamp, and viewing the light as it passed through a slit on to a glass prism, he obtained a certain dark line in the spectrum that represented sodium. He communicated his discovery to Lord Kelvin, who immediately introduced the experiment in his Glasgow lectures, and announced that, as a consequence of this discovery, solar and stellar chemistry had become possible.

Following Stokes, he pointed out that the way to find other substances besides sodium in the sun and stars was to compare the bright lines produced by each element burning in an artificial flame with the dark lines seen in the spectra of heavenly bodies. The discovery of this extraordinary method of analysing the flaming matters of sun and stars is usually attributed to Kirchhoff, who also worked it out in 1859.

But there is a letter from Kelvin to Stokes, dated March 9, 1854, in which he says, "You told me about the experiment a long time ago."

The fact was, Stokes was always over-cautious by temperament. He refrained from publishing his discovery at the time, because he doubted whether the effects might not be due to some constituent of sodium supposed to be broken up in the electric arc or spirit-lamp flame. But his facts and theories were sufficient to convince Kelvin, and would certainly have convinced many other men of science. Unhappily, Stokes became secretary of the Royal Society in 1854, and his administrative duties took up so much of his time that the amount of his scientific work was diminished. Among other things that he had to drop was the development of the great discovery of his life—solar and stellar chemistry. His over-cautiousness was also largely responsible for the prevention of the complete discovery of electric waves by Professor Hughes, who was using, long before Hertz took up the matter, his telephonic microphone in detecting the waves. Stokes died on February 1, 1903.

ROBERT JOHN STRUTT

A Brilliant Father's Brilliant Son

The Hon. Robert John Strutt, a distinguished physicist of the younger school, was born on August 28, 1875, and was educated at Eton and Trinity College, Cambridge. The eldest son and heir of Lord Rayleigh, co-discoverer of argon, Mr. Strutt inherits a faculty for science, and is already distinguished in the pursuits which rendered his father world-famous. The Strutts, father and son, are a supreme puzzle to many American business men. The latter can understand that practically self-made men, such as Lister and Kelvin, should toil through the exhausting labours of the avowed scientist, but that men born to wealth and to a peerage should undertake the burden of such thankless research is to them incomprehensible. But in the Strutt family son follows father—to as fine results, we all hope. In 1865 John William Strutt, now third Baron Rayleigh, was Senior Wrangler, and for five or six years Professor of Experimental Physics at Cambridge. In 1897 Robert John Strutt, heir to the barony, took a First Class in the Natural Science Tripos, and three years later became a Fellow of his College. To-day he holds the proud position of Professor of Physics at the Imperial College of Science, South Kensington, and is a foremost authority on radio-activity.

It was in conjunction with Sir William Ramsay that Lord Rayleigh made his discovery of argon. On the strength of Ramsay's discovery that radium slowly evolves helium, Mr. Strutt was enabled to carry forward the work of his father's old partner in science, and reveal to the world the fascinating story of the hidden mystery of Bath. Helium was found to issue from the best known of the hot mineral springs of Bath, and a thoughtful corporation caused deposits from the pipes and tanks to be forwarded to Mr. Strutt. After analysis, Mr. Strutt was able to announce that the red mud forwarded to him from the spring contained radium in appreciable quantities. "When I speak of 'appreciable quantities,'" he wrote, "I mean quantities such that its presence may be easily detected. But the percentage of radium in the deposit is very much less than that in the ores from which it is now obtained."

ROBERT JOHN STRUTT
Photograph by Lafayette

Mr. Strutt has conducted valuable original investigations into the nature and phenomena of radio-active matter. The special value of his writings upon science to the general public lies in their extreme lucidity and attractiveness. He possesses the inestimable faculty of making an abstruse

and recondite subject "live." When the average scientist takes pen in hand, what he writes is frequently repellent to all but the initiated, who need no textbooks. It was with Mr. Strutt that there originated the suggestion that the mysterious X-rays consist of positively charged bodies projected with great velocity; and the experiments and theory of the young scientist were within a year confirmed and adopted by Sir William Crookes, who made all the experiments possible. Mr. Strutt's tests show that helium is very generally encountered in all minerals; and there is reason to hope that his further researches, with those of the brilliant school of younger physicists to which he belongs, will succeed in carrying us to a point from which our present-day knowledge will appear but the A B C of the subject of his special interest.

SILVANUS PHILLIPS THOMPSON
Photograph by Elliott & Fry

SILVANUS PHILLIPS THOMPSON
A Master of Electrical Science

Silvanus Phillips Thompson comes of Quaker stock, and was born at York on June 19, 1851. He was taught at the Friends' School in York and at the Flounders' Institute, Pontefract; he also studied at the Royal School of Mines, and continued his scientific training at Heidelberg. In 1878 he took his degree of doctor of science, and in the same year he was appointed Professor of Experimental Physics at Bristol. In 1885 he became Principal of the City and Guilds Technical College at Finsbury, where he has done much fine work both in training electrical engineers of the younger generation and in original research on the problems of magnetism and electricity.

It was in 1883 that he made himself known as a master of modern knowledge. His Cantor Lectures of that year showed him to be a leader in the science and practice of electro-dynamic machinery. He then took up the study of the electro-magnet, and after working for seven years on this subject he discoursed upon it in the Cantor Lectures of 1890. Five years afterwards, his work on the arc light, by which he is perhaps most generally known, was also published in the form of lectures. He has contributed to the science of optics, improved the telephone, and made important researches on high-speed electric machinery in connection with the steam-turbine. He is, indeed, one of the most versatile of our physicists of the experimental school; he touches no branch of knowledge that he does not advance.

Genial in temperament, and a lover of fine conversation, he is one of the ornaments of that quaint and brilliant club the Sette of Odd Volumes; and his interest in antiquarianism has led him to become an admirable historian of electrical science. He possesses a choice collection of the earliest books on electricity and magnetism; and for Gilbert of Colchester, on whom he has written several times, he has an impassioned devotion. He is also an artist, and his water-colours and black-and-white sketches and etchings show a good deal of native talent. As a trainer of electrical engineers he is unsurpassed by any other man. Not only is he very patient and painstaking, but he has the art of discovering the bent of mind of his numerous students, and encouraging them in the development of their special faculty.

SIR J. J. THOMSON
The Discoverer of Ultimate Matter

Sir Joseph John Thomson, perhaps the greatest of living men of science, was born near Manchester on December 18, 1856. His interest in scientific research was developed at Owens College, Manchester, and he was well trained in experimental work when he went up to Trinity College, Cambridge. Here he distinguished himself

by his talent for mathematics, and graduated as Second Wrangler and second Smith's Prizeman in 1880. In the same year he became a Fellow of Trinity, and, taking up Sir William Crookes's theory of radiant matter, began to work, in 1881, at the electrical and magnetic effects produced by the motion of electrified bodies.

Crookes had succeeded in creating a high vacuum in a glass tube, and had sent a discharge of electricity through this vacuum, and produced a stream of radiant matter in the tube. This stream of luminous particles has been developed into a thing of the highest importance by increasing the vacuum in the tube. From it the X-ray has been obtained, and from it Sir J. J. Thomson has attained results which have overturned the foundations of the two related sciences of physics and chemistry.

It was in 1897 that Sir Joseph made his great discovery. He placed powerful electro-magnets outside the vacuum tube, and then acted on the luminous stream of particles by means of an electric current flowing into the electro-magnets. By finding out the exact amount of electrical energy necessary to counteract the electric charge on the radiant stream in the tube he was able to calculate the amount of electricity on each of the luminous particles. He also measured the speed with which the particles moved in the vacuum tube. Having thus obtained by actual experiment a knowledge of the electric charge and the velocity of the particles, he was able to ascertain their mass or size. He expected it to be that of an atom, for he thought that the luminous particles produced by the electric discharge were formed of atoms. He discovered, however, that the particles were two thousand times smaller than the smallest known atom.

This was so staggering a discovery that Sir J. J. Thomson sought for some other means of checking the results he had obtained. One of the most brilliant workers in his laboratory, Mr. C. T. R. Wilson, had found that electrified particles of matter acted as centres of condensation for water-vapour. Thomson introduced steam into his vacuum tube, so that the water-vapour condensed on each single corpuscle into which the atom had been broken. By measuring the visible mist formed by the condensation of water, he was able again to show that the particles in his vacuum tube were much smaller than atoms. They were, in fact, the ultimate stuff out of which everything in the material universe is made.

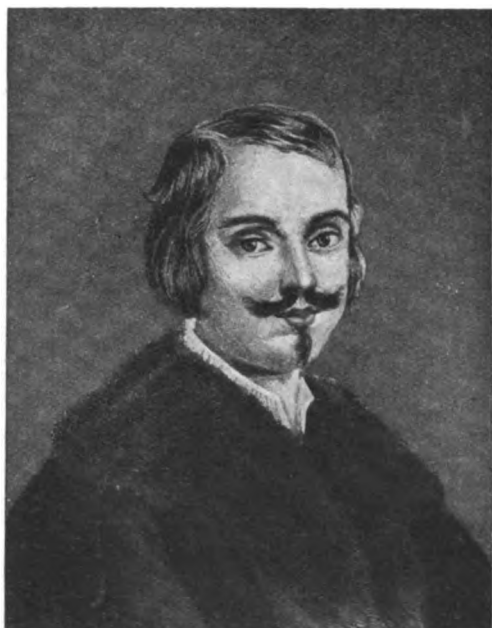
Two thousand times smaller than the smallest atom, they were formed of charges of electricity in motion, and atoms were built out of them in somewhat the same way as our solar system is formed of a series of planets whirling around the sun. The sun of an atomic system, so to speak, is a large centre of positive electricity; the planets are small centres of negative electricity. An electrical discharge through the rarefied gases of a vacuum tube breaks some of the planets of an atomic system from the main body, and sends them in a stream of luminous particles against the glass wall of the tube. On striking against the glass, the electrons, as the inconceivably minute par-

SIR JOSEPH JOHN THOMSON
Photograph by W. H. Hayles

ticles are now called, set up a series of electrical waves. These electrical waves are so minute in length that they are quite invisible. They penetrate through wood and flesh, and other material obstacles. They are the X-rays that Röntgen discovered.

If electrons are the ultimate stuff out of which atoms are formed, they should be found in radium, whose strange rays are produced by the breaking up of a radium atom into a helium atom. This has been done, and there are several other curious modern discoveries which confirm the experiments made by Sir J. J. Thomson in 1897. He announced the result of his experiments at a meeting of the British

Association in 1899; and though some Continental physicists at first vehemently opposed his views, his facts and ideas have now become the base of modern chemistry and modern physics.

Recently Sir Joseph has studied another variety of luminous particles which can be produced in a vacuum tube. These particles are atoms charged with positive electricity. By fixing a photographic camera at one end of the glass tube, evidence is obtained that an electric discharge through various kinds of rarefied gases results in the creation of numerous varieties of substances hitherto unknown by man. It is extremely likely that very few of these substances exist on earth, save when they are created by Sir Joseph and the men who follow down the new paths of science that he opens. His method is really a kind of spectrum analysis, but it is much more delicate and subtle and far-ranging than any sort of spectroscope. Since 1884 Sir Joseph has been Cavendish Professor of Experimental Physics at Cambridge, and he has trained some of the leading physicists in all parts of the civilised world. His pupils are, indeed, as important a part of his work as his actual discoveries. Indeed, some of them almost equal their master in originality, range, and power of mind. A man of fine nature, Sir Joseph takes more pride in the achievements of the men who worked under him than he does in his own discoveries.

EVANGELISTA TORRICELLI

EVANGELISTA TORRICELLI

A Columbus of the World of Air

Evangelista Torricelli, the inventor of the barometer, was born at Faenza, in Italy, on October 15, 1608. He was brought up by an uncle, an enlightened and thoughtful man, who remarked that the boy was of an inquiring turn of mind, and sent him at the age of nineteen to Rome to study under Castelli, a famous professor of mathematics. Castelli had been entrusted by Pope Urban VIII. with some hydraulic undertakings, and in helping his master in this work Torricelli was inspired to make some experiments with water that had important results.

After reading the works of Galileo, the young Italian took up the study of fluids in motion, and he found that water in movement acted in the same way as a projectile or thrown body. Galileo had worked out the parabolic movement of projectiles, and by applying his ideas to the motion of water Torricelli founded the science of hydro-mechanics.

The young man of science sent a paper on his discovery to Galileo, who was then living at Florence, broken in health and old in body, but still alert and vigorous in intellect. The great Italian invited the young man to come and stay with him, and in 1641 Torricelli went to Florence, and lived for three months with the master of modern science. But Galileo, then seventy-eight years old, died while Torricelli was still studying under him.

By this time the genius of Torricelli was fully matured. After his master died there was no man in Florence equal to him in power and originality of mind. So he was appointed professor of mathematics and physics in the place of his dead master. He carried on the science of optics, which Galileo had introduced into Italy, and improved the microscope, but his chief work was still the study of water. He made some very important discoveries in regard to the flow of liquids through a small orifice in 1643, and about the same time he invented the modern barometer.

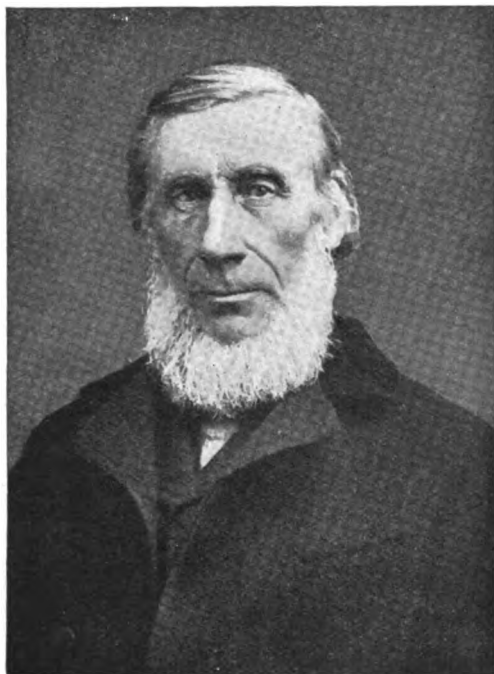
Galileo had observed that water would only rise about thirty-two feet in a perpendicular direction in the suction-pipe of a pump. This fact had, indeed been discovered by many engineers when attempting to raise water to a greater height for the purpose of making ornamental fountains in the gardens of wealthy noblemen. It is possible that Galileo suggested to Torricelli the explanation of this curious behaviour of water, but it was only a suggestion. It

was Torricelli alone who developed the theory of atmospheric pressure, and devised the experimental proof of his ideas. He reasoned that if it was the weight of the atmosphere that forced the column of water to a height of thirty-two feet in an upright pipe, then a heavier liquid would be impelled to a less distance in a perpendicular tube. He filled a small glass tube with mercury, and then inverted it in a dish that was partly filled with the same heavy liquid. Instead of all the mercury in the tube running into the dish, some of it remained in the tube, held there by the pressure of the atmosphere on the surface of the mercury in the open dish.

What was more important was the fact that the height at which the mercury stood in the tube corresponded with the height that a column of water of the same weight would occupy under similar conditions. Torricelli thus proved that a long column of water or a small column of mercury was each a measurement of the pressure exerted by the atmosphere. Torricelli showed his discovery to Viviani, and in 1643 the two men constructed their first barometer. But it was Torricelli alone who perceived the extraordinary powers of the new instrument. He studied the variations of pressure from day to day, and in 1644 he made his crowning discovery. He announced that a column of quicksilver would give a measurement of the continual changes in the pressure of the atmosphere. The measurement of these changes, he added, had been the object of his experiments. There can be little doubt that he would have proceeded to demonstrate the great practical value of the new instrument of science which he had gradually elaborated. Unhappily, he fell sick, and by his early death, on October 25, 1647, the new science of the atmosphere was left to Pascal and other men to develop. Still, he remains the Columbus of the world of air.

JOHN TYNDALL

Experimenter and Expounder

John Tyndall, physicist and foremost expounder of science, was born at Leighlin Bridge, County Carlow, Ireland, on August 21, 1820. His father, a worthy member of the Irish Constabulary, not only gave him the best education available at the local national school, but himself took a share in his son's training, devoting special attention to theology. With a good knowledge of elementary mathematics, Tyndall was engaged, at nineteen, on the Irish Ordnance Survey, passing, three years later, to the English Survey. This move carried him to Preston, in Lancashire, where he became a member of the Mechanics' Institute, and then, like Herbert Spencer, with whose name his own was afterwards to be associated, he became a railway engineer. The ardent desire which long possessed him for life in the New World now first expressed itself, but failure to obtain the post he sought induced him, when twenty-seven, to accept a mastership in mathematics and surveying at Queenwood College, in Hampshire. Queenwood was originally built by Robert Owen as a Hall of Harmony Settlement, and the "C. of M." carved upon its face still remained

JOHN TYNDALL
Photograph by Elliott & Fry

to express the philanthropist's vain hope as to the "Commencement of Millennium." Here Tyndall met Edward Frankland, who was destined to achieve considerable fame as a chemist, and a helpful friendship sprang up between the two young men, Frankland inducting Tyndall into the mysteries of chemistry, while Tyndall instructed him in mathematics.

Within a year the two comrades threw up their positions at Queenwood, and went to Marburg to study under Bunsen, who, while Europe was seething with political excitement which set thrones rocking and crowns toppling, was quietly working away,

in the finest laboratory in Europe, at researches which gave us the Bunsen burner, magnesium light, and, in conjunction with those of Kirchhoff, opened to us a new world through the agency of spectrum analysis. Under this able mentor Tyndall crowded a three years' course into two years. He there began his investigations into diamagnetism and the magneto-optic properties of crystals, which, introduced by Sir Edward Sabine, famous for his labours in terrestrial magnetism, to the notice of the Royal Society, gained Tyndall a Fellowship of that body when thirty-two years of age. Tyndall's hard work at Marburg had brought him his degree of D.Sc., however, two years prior to this, and, more important still, he had already made the acquaintance of Faraday and Huxley. A cordial friendship sprang up between Huxley and Tyndall, and they applied in company for Chairs at Canadian and Australian universities, where the authorities, not having the gift of divination, rejected the highly recommended young scientists, to the great gain of the Motherland. Toronto had wanted Lyon Playfair nine or ten years earlier, but they would have none of Huxley or Tyndall.

The last-named had to worry through a considerable amount of work at Berlin, and to read papers before two of the British Association meetings, before he gained recognition in England. It was on the strength of his Berlin record, ferreted out in the German capital by Bence Jones, that he was invited to deliver one of the Friday evening lectures at the Royal Institution. He attained success at a bound. Within three months he was appointed professor of natural philosophy at the institution, where Farday was then engaged on his famous electrical and physical experiments.

Although differing profoundly in their religious views, the two men worked together with the greatest cordiality, and Tyndall's biography of Faraday was one of the most charming things he ever wrote. When Faraday died, Tyndall, in 1867, succeeded him as superintendent of the institution, having by that time securely established himself, no less by original work than by his supreme gifts of exposition, as one of the foremost of our men of science. A visit with Huxley to the Alps led to their jointly beginning the study of glaciers which Tyndall was afterwards long to carry on alone. Others had already worked on the problem as to how an apparently solid mass of ice can "flow"—Tyndall finally elucidated the mystery. Years of waiting and watching went to the work before he was able at last to show that the veined structure of the glacier is due to mechanical pressure, and the formation of crevasses to strains and pressures occurring in the body of the glacier. The flow of the river of ice is due, he showed, to fracture and regelation—that is, the phenomenon presented by portions of moist ice which, when placed in contact with one another, freeze together even in a warm atmosphere.

His work on glaciers had an important effect upon his scientific work, for it led to his investigations on radiation, perhaps his most important work. Indeed, his "Radiant Heat in its Relation to Gases and Vapours" would alone have sufficed to ensure his position among scientists. The experience gained during the years over which his study of this and cognate subjects extended enabled him to render valuable service as expert adviser to the Board of Trade and Lighthouse Authority. His results gave new data to meteorologists, while also affording invaluable knowledge as to the best medium for lighting dark seaways and transmitting danger-signals by sound to ships befogged.

Many of Tyndall's experiments were of the most refined and interesting character, and productive of highly practical results, while also extremely attractive as scientific displays. One such resulted in the discovery of what is termed the vowel-flame—a flame which is variously affected by the utterance of different vowel-sounds. Another led to the discovery of the cause of the sky's being blue. This latter was part of a series of experiments which produced important results. Dust in the atmosphere gives us the blue of the sky and the glory of the sunset, but a dust-free atmosphere renders light invisible. If air can be rendered dustless, it can be rendered germless, he thought. He proved this to be the case—that food can be preserved indefinitely in air or fluid from which all bacteria are excluded. But to make sure that germs already secreted in the food or fluid shall not develop when the parent organisms have perished, he proposed not one excessive heating but successive or discontinuous heatings, which first develop, then utterly destroy, the most refractory organisms. This discovery is of great scientific and commercial value.

Apart from original research work, Tyndall was of importance to his generation, for he could express difficult scientific

truths in languages which the man in the street could understand. He popularised science in the best sense of the term. He had great influence for good when Darwin appeared with his world-shaking announcement in the "Origin of Species." At first Darwin was allowed to rely for support upon the biologists; physicists held aloof. But Tyndall came boldly forth as a champion of the new doctrine, and from that time forth was generally recognised as one of the prime leaders in the great revolution in thought of the nineteenth century. Darwinism was bound to triumph in the end, but Tyndall, Spencer, and Huxley together constituted a driving force which all the energies of the opposition were powerless to withstand. Tyndall had a unique position; he stood for physics, for the Royal Institution, for orthodox science blended with the new, and his espousal of Darwinism had enormous weight with the general public. He retained his position at the Royal Institution up to 1887, when ill-health caused him to resign, and to retire to the beautiful home he had built at Hindhead. He died there from an overdose of chloral, taken to induce sleep, on December 4, 1893. His fame really culminated in 1874, when he was President of the Royal Association. In his presidential address he made a warm attack on orthodoxy, and was denounced for expounding what opponents described as "rank materialism."

PROFESSOR TYNDALL'S WORKSHOP NEAR HIS HOME AT HINDHEAD, SURREY

JACOBUS HENRICUS VAN'T HOFF

Revolutioniser of Organic Chemistry

Jacobus Henricus Van't Hoff, the Newton of chemical science, was born at Rotterdam on August 30, 1852, the son of a physician of that town. He was educated at Leyden, and studied afterwards at Bonn and Paris. Early in 1874, when he was a student of twenty-one, he published a pamphlet of a few pages announcing a discovery of the highest importance. It provided a new foundation for chemistry. It had been known for some years that certain substances produced by living bodies could agree in the number and quality of their atoms, and yet be entirely different in their nature. Forms of matter, apparently

identical in composition, had been found to possess different melting-points, boiling-points, and crystalline shape, and other chemical properties.

The mistake arose through chemists merely drawing maps of the atomic structure of substances. Van't Hoff pointed out that a map did not represent the arrangement of atoms in certain compounds, for, besides length and breadth, there was the third dimension of depth. He showed how the atoms of various carbon compounds were arranged in a three-dimensioned space, so that, although the atoms of two substances were identical, their arrangement in space was different.

He had become in 1876 a lecturer at a Dutch veterinary college; and when his new idea began to be discussed he was told by his opponents that he had mounted a lame horse that would not carry him very far. As a matter of fact, all the best work in organic chemistry since 1874 is based upon his discovery of carbon compounds with the atoms arranged in space. He showed modern men of science that in order to connect many synthetical products it was not sufficient merely to bring together certain elements with a given amount of atoms. The atoms had to be arranged in a new way. This new science that he founded when hardly more than a boy is called stereochemistry. It is one of the most valuable of the modern fields of knowledge.

In 1877 Van't Hoff went to Amsterdam as a lecturer, and in the following year was appointed professor of chemistry. Again he struck out an original line of research, and developed the law of mass-action, and placed chemical dynamics and chemical equilibrium on a sure basis. He demonstrated that the relation between chemical affinity and heat-effect was similar in form to the relation between electrical energy and heat-effect. By this means he brought the ultimate problems of chemical action into connection with problems of electricity, and cleared the way for the discovery that all forms of matter are made up of centres of electrical energy.

In 1885 Van't Hoff opened out another field of chemical science in his study of osmotic pressure. If a semi-porous earthenware pot is filled with sugar-water, and then placed in a larger vessel full of pure water, which is heated, the pure hot water will force its way into the pot, and the pressure exerted on the walls of the earthenware pot will increase. This pressure is called osmotic pressure, and it can be so increased that it will keep any more water from entering the pot. Osmotic pressure exists when two different solutions are divided by a semi-permeable membrane. All this may seem a simple and insignificant affair, but Van't Hoff achieved the greatest work of his life by discovering the law of osmotic pressure. He showed that a solution exerts the same osmotic pressure on the walls of a semi-porous vessel as a gas would do. In other words, he reduced the actions of solutions to the law that Boyle and Gay-Lussac had discovered for gases.

All ordinary solutions at once became attackable in a new way by men of science. Not only was a new field of knowledge opened in chemistry, but some of the most difficult problems in the study of the processes of life were illuminated by the great Dutchman's discovery. The protoplasm of the living cell is a kind of solution enclosed in a semi-permeable membrane; and partly by the action of the membrane, and partly by the osmotic pressure of the protoplasm, the action of life goes on. When the cells of the sugar-beet are surrounded by warm water, the sugar-content of the cells is dissolved in the water that passes in and out of the membrane, until all the sugar is extracted from the cells and diffused in the surrounding water. By this method beet sugar is now generally made. Thus the problems of osmotic pressure have an important bearing upon industries as well as upon problems of physics, biology, and chemistry. So Van't Hoff's apparently simple law that solutions act like gases is a discovery of high and wide importance.

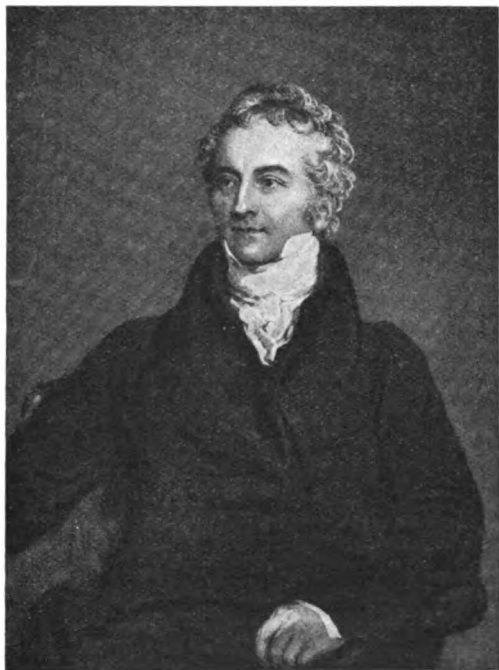
In 1896 the great Dutchman received a remarkable offer from Berlin. Two years previously the Chair of Physics at the German capital had been refused by him, but in order to attract and honour him the Prussian Academy of Science next offered him the Berlin Chair of Chemistry, with a salary and a fine laboratory, on the condition that he should undertake no duties except those that he cared to assume. No honour such as this has been paid in Germany to any foreign man of science since the time of Frederick the Great. Van't Hoff became a member of the Prussian Academy, and at Berlin he again struck out in a novel and extraordinary line of research. He took up the study of the salt deposits of the oceans, and by combining chemical experiment with geological observations he established another new science—experimental geology. He made artificial oceanic

deposits in his laboratory, and then from the knowledge thus obtained he worked out the time necessary for the formation of naturally produced beds of minerals.

In person, Van't Hoff was a man of striking appearance, with a frank, modest, and unselfish character. When he died, on March 1, 1911, it was said by an English writer of authority that he had shown himself to be " one of the greatest geniuses the world has ever seen." His work is not remarkable for its mass. It is by the force and originality with which he discovered and developed a few magnificent ideas that he revolutionised organic chemistry, founded the science of solutions, related chemistry to electricity, and created a new era in geology. His work on solutions is perhaps his masterpiece. The greater part of chemical reactions takes place in solutions; and out of the behaviours of salts dissolved in a liquid many valuable industrial processes and electro-chemical theories have been evolved. There are also solid solutions, such as occur in the manufacture of steel; and the protoplasm of a living cell behaves in many respects like a real solution. Over all these fields of new knowledge reigns the genius of the great Dutchman. At present we stand too near the achievements of Van't Hoff to appreciate their full importance. Like Newton's discovery of the law of gravitation, the laws of Van't Hoff are magnificent instruments for larger additions to the temple of human knowledge, and their worth will only be entirely known when a later generation has built upon the foundations he has laid.

THOMAS YOUNG
Who Upset Some of Newton's Ideas

Thomas Young was born at Milverton, in Somerset, on June 13, 1773. His parents belonged to the Society of Friends, and Young himself refused a first-rate Government position in early manhood merely because its acceptance would have made it necessary for him to give up his Quaker dress. Young was brought up by his grandmother and his aunt, who taught him so well that his mind was matured at too early an age. But the poor instruction he afterwards received at a boarding-school near Bristol checked his precocity by throwing him on his own resources. His education was largely his own work. He learnt from books, tackling the higher mathematics and the science of optics, making a microscope for his own use, besides acquiring an uncommon range of languages. He knew Greek and Latin at nine, and he picked up Italian and mastered Hebrew. At fourteen, when he began to earn money as a tutor, he was able to translate parts of the Bible into no fewer than fourteen languages.

From the beginning he did nothing by halves. On whatever branch of study he entered, he mastered and pursued it throughout his life. His study of optics enabled him to disprove Newton's theory that light was produced by minute particles of matter ejected from the sun and other burning bodies. His study of languages enabled him to discover, first of all men, the meaning of the characters of the ancient writings of Egyptians.

THOMAS YOUNG

At twenty-one he came to London to study as a doctor, and at once attracted the notice of the best minds of his age. Burke, Windham and Sir Joshua Reynolds became his friends. He pursued his medical studies with characteristic thoroughness, and while but a student he applied his knowledge of optics to the action of the human eye, and showed that power of vision is accommodated to near and distant objects by the alteration of the curvature of the crystalline lens. His view was much disputed at the time, but many years afterwards it was found to be correct. To complete his medical education, he went

to Edinburgh, and then to Göttingen, and there distinguished himself by his studies on sound. From Germany he proceeded to Cambridge, still thirsty for knowledge, and remained there for six years. A rich uncle, proud of his brilliant nephew, paid for his medical training, and further left him a considerable fortune.

Three years afterwards, while still studying at Cambridge, Young began the investigations on which his fame chiefly depends. Following up his work on sound-waves, he showed that these waves could be reflected back so as to interfere with each other. It then struck him that the theory of the existence of the waves of light might also be established as an actual fact if it could be shown that when two trains of light-waves, coming in opposite directions, met and checked each other, darkness was produced instead of light. At the time light was still one of the great mysteries of science. Newton and Huyghens had each put forward a theory on the matter. Newton considered the sensation of light to be due to inconceivably minute particles of matter impinging against the retina. Huyghens, on the other hand, attributed the sensation of light to the impact of minute waves. Neither theory had been established by experiment, and both were apparently invalidated by certain observations.

Young settled the problem by studying soap-bubbles, and showing how the colours of these thin films were produced by the interference of direct and reflected trains of light-waves. Where the two opposite sets of waves met, they interfered with each other, so that some of the waves of colour usually seen as a white light were partly stopped and transformed into colour-effects. As a white light is made up of innumerable waves of different lengths, such waves cannot all interfere at the same time. Some interfere totally and destroy each other, some interfere partially, while some add themselves together and enhance the effect. Thus, by interference, a portion only of the white light is destroyed, and the remaining portion is usually coloured.

In another experiment Young used Newton's own weapons—known as Newton's rings—to prove that light was produced by trains of waves. Unfortunately, a man who knew little or nothing about science, but who possessed a remarkable power of invective, came forth in the "Edinburgh Review" as a defender of Newton. The man was Lord Brougham. He was one of the most popular writers of the time, with a talent for sarcasm unequalled by any other writer. So complete was his attack on Young that only a single copy of the reply that Young made was sold by the booksellers. For thirteen years Young remained under a cloud; and it was not until his magnificent discoveries were repeated by a French man of science, Fresnel, that the effect of Brougham's attack was annulled.

In the meantime, Young resigned his post at the Royal Institution and devoted himself to the practice of medicine, becoming physician to St. George's Hospital. His mind, said Helmholtz long afterwards, was one of the most profound the world has ever produced, but he had the misfortune to be too much in advance of his age. In another direction the fame of Young has suffered through the neglect of his own countrymen, and through the admirable alacrity with which the French recognised the work of Frenchmen. In 1799 the famous Rosetta Stone was discovered in Egypt. It was inscribed with a Royal decree, written in Greek and in popular script and in the ancient hieroglyphics. Copies of the three inscriptions were published by the Societies of Antiquaries, and in 1814 Young began to study them. In three months he found that some of the so-called popular characters were also hieroglyphics, and by 1818 he had determined nearly a hundred characters of the hieroglyphic text. Then, using papyri from Egyptian graves, he obtained about two hundred characters. A popular sketch of his results was published in the "Encyclopædia Britannica" in 1819. In 1821 Champollion wrote a memoir, which he rapidly suppressed, and in which he confessed he had made no progress in ascertaining the meaning of the hieroglyphical characters. Champollion suppressed his memoir after reading Young's article, and in 1828 he published Young's early discoveries over his own name. Tyndall went thoroughly into the matter in 1888, and showed very clearly that Champollion tried to prevent Young from obtaining the document he needed to repeat his researches. After failing to do this, the Frenchman suppressed his own confession of ignorance and robbed Young, without acknowledgment, of his discovery of the meaning of both kinds of Egyptian characters—the sacred and the so-called popular script. Thomas Young died on May 10, 1829, at the age of fifty-five.

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BIOLOGISTS

SIR JAMES PAGET
A Modern Master-Surgeon

SIR JAMES PAGET was born at Yarmouth on January 11, 1814. He desired to join the Navy, as he tells us in his delightful and well-known Memoirs, edited by his son, Mr. Stephen Paget, but fortunately this plan was abandoned, and he became apprenticed to a doctor at the age of sixteen. When he was twenty he went to St. Bartholomew's Hospital, and there, as a first-year student, by means of a pocket lens, he found the trichina spiralis, or tiny worm that enters the human body from infected pork and causes the terrible disease called trichinosis. This was only the first of many discoveries in pathology that stand to the record of this master among surgeons—a master who was so much more than a surgeon.

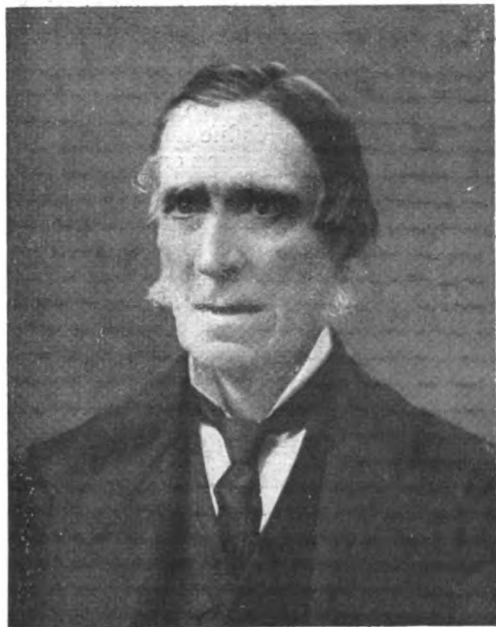
After many years of hardworking penury—for his once wealthy father, a brewer and shipowner, had failed in business—Paget at last obtained, in 1847, a post in some degree worthy of him—a Chair at the Royal College ot Surgeons. There he gave those "Lectures on Surgical Pathology" which made a stepping-stone from the past to the surgery of Lister. Today, even, those great lectures remain classical and authoritative. Paget was elected to the Royal Society, and took his place as a leader in the study of disease, but, as his son tells us, "he had hardly begun to get into practice, and he had kept himself poor that he might pay his share of his father's debts—a task that it took him fourteen years to fulfil."

Paget was the John Hunter of his day. As a youth he had looked more closely through a pocket lens at a scrap of muscle than other people, and had made a discovery which enables us to prevent trichinosis. All through his life he was a master of the microscope, carrying on the study of disease from the point at which he found it, and searching the facts of all morbid processes as they can be seen through lenses. Today the microscope is more important than ever, and yet less so, for the chemical study of disease has arrived, and takes us a stage further in analysis; but every living pathologist, whatever his methods, stands firmly upon the shoulders of the Englishman Paget, and his great German contemporary, Rudolf Virchow.

At last Paget obtained what he had never worked for—material success. The days when he could only make £15 a year in practice were over. He became surgeon to Queen Victoria and her heir, and was for a long period the first surgeon in the land. In 1871 he was made a baronet, in 1875 President of the Royal College of Surgeons, and subsequent honours were many and world-wide. He wrote freely, but his lectures, published in 1853, are his supreme work. His name is daily in the mouths of doctors throughout the world, for it is attached to a malady of the breast, and to a very remarkable disease of the bones, both of which he discovered. All who knew him speak of him with devotion and homage.

Students of pathology, and of the yet nobler science of noble living, should consult the most interesting "Memoirs and Letters of Sir James Paget," published in 1902. Sir James Paget tells us in these

Memoirs that his father died "at eighty-two, of that most rare of all the causes of death—mere old age. He had never once been ill, and in the time of his gradual decay nothing erred from its just proportion in the work of life; only there gradually became less of everything belonging to this life, and in due time everything slowly and coincidently ceased." Much the same might be said of himself. He gradually relaxed his work, and died, at a greater age than his father's, on December 30, 1899.

Much more should be added, however, for the student of heredity. Paget's eldest son, Sir John Paget, is a great authority on banking. His second son, Francis, became Bishop of Oxford, and wrote many religious books. The third son, Henry Luke, is Bishop of Stepney. The fourth son, Stephen,

SIR JAMES PAGET

is a distinguished surgeon, author of many valuable books, and honorary secretary of the Research Defence Society.

AMBROISE PARÉ
A Forerunner of Modern Surgery

Ambroise Paré was born at Laval, in Maine, in 1517. His experience, like that of so many surgeons in the past, was chiefly military. He saw much of war, and was surgeon to many kings.

In the treatment of wounds Paré did something in the antiseptic direction, for he used turpentine, though little good can have come from the boiling oil which he employed at first. When his oil ran short on a certain occasion, as things needed for the wounded still run short on battlefields, Paré was compelled to use something else. It was turpentine that he hit upon, and the results were so good, even though the boiling oil had been abandoned, that, as he tells us, he "resolved never more to burn thus cruelly poor men with gunshot wounds." Having estimated the antiseptic properties of turpentine today, and knowing what are the enemies of wounds, we can understand why the method thus forced upon Paré was so successful.

At Turin there was a surgeon who had a famous remedy for gunshot wounds. After two years of persuasion and gifts, he consented to tell Paré his formula. "In the end, thanks to my gifts and presents," says Paré, "he gave it to me, which was to boil, in oil of lilies, young whelps just born, and earth-worms prepared with Venetian turpentine. Then was I joyful, and my heart made glad, that I had understood his remedy, which was like that which I had obtained by chance." So much for the earliest blind gropings, before the dawn of modern science, for an antiseptic system of surgery. Yet when Paré had a compound fracture himself, white of egg, flour, soot from the chimney, and melted butter were applied to the wound of the greatest surgeon of the sixteenth century!

At the best, results were bad enough in those days. Paré declared that the King of Navarre's wound was certainly mortal, because a great joint was injured, and "all wounds of great joints are mortal." Today such joints are constantly opened, for the relief of local trifles, like a loosened cartilage in the knee-joint. Yet we owe much to Paré for the great advance he made by the abolition of boiling oil, and the use of turpentine, which, however, is still employed by surgeons, at least in the form of soaps and lotions for cleansing the skin before operations.

In 1561 Paré's great work on surgery, the "Cinq Livres de Chirurgie," was published at Paris. These mark and make an epoch in the history of surgery. But the greatest of all his services to surgical science and practice was the introduction of the ligature. In his day, when limbs were amputated—this being the chief routine task of surgery in the days of constant war and ignorance of conservative methods of saving limbs—the bleeding from the cut

arteries was arrested by means of a red-hot iron. They were cauterised, and so closed. Of course, there were no anæsthetics in those days. Paré, merciful and original, who had already relieved "poor men" from torture with boiling oil, now daringly introduced the method of tying the arteries instead of burning them. To him we owe the ligature—*i.e.*, the piece of thread, silk, horsehair, or, thanks to Lister, catgut, by which arteries may be tied. We may faintly imagine what this was worth to soldiers, wounded in the quarrels of the "great," who would otherwise have had to face the red-hot iron. Finally, we have advanced from Paré's turpentine, so that wounds heal as

AMBROISE PARÉ AT THE SIEGE OF METZ
From the painting by Chartran, at La Sarbonne, Paris.

they should, and ligatures do not break off, with renewed bleeding, as in the days when microbes were allowed to spoil the natural process of healing.

The "natural process," we say. Paré, with his deep and prophetic vision, knew what he witnessed, and what was the real duty of the surgeon, a duty which, thanks largely to him, the surgeon of today can fully discharge. When praised for his success with a certain patient, he replied, "I dressed his wounds; God healed him."

This bold, humane, profound surgeon died in Paris in 1590, and will be one of the glories of France to the end of time. His Life may be read in English in an admirable volume by one of his contemporary followers, Mr. Stephen Paget.

LOUIS PASTEUR
The Founder of Preventive Medicine

Louis Pasteur was born at Dole on December 27, 1822. The boy showed exceptional qualities, and was intended for an academic career in chemistry. He studied at Besançon, and then in Paris, where he came under the influence of such great chemists of their day as Biot and Dumas, who thought highly of their young pupil. He earned his living, and obtained opportunities for research, in the usual fashion, by teaching posts in various universities, and he became professor of chemistry at the Sorbonne in 1867. From first to last, his was the chemical point of view, and students of chemical science rank him as a master and epoch-maker, just as the pathologist or the hygienist does. Indeed, so remarkable was his initial success in chemistry that his distinguished teachers deplored his attention to certain peculiar phenomena which were outside the domain of chemistry, and from which, they thought, nothing worthy of the ability of the young student could proceed. But modern medicine, surgery, and hygiene thence proceeded.

Pasteur's first research revealed his

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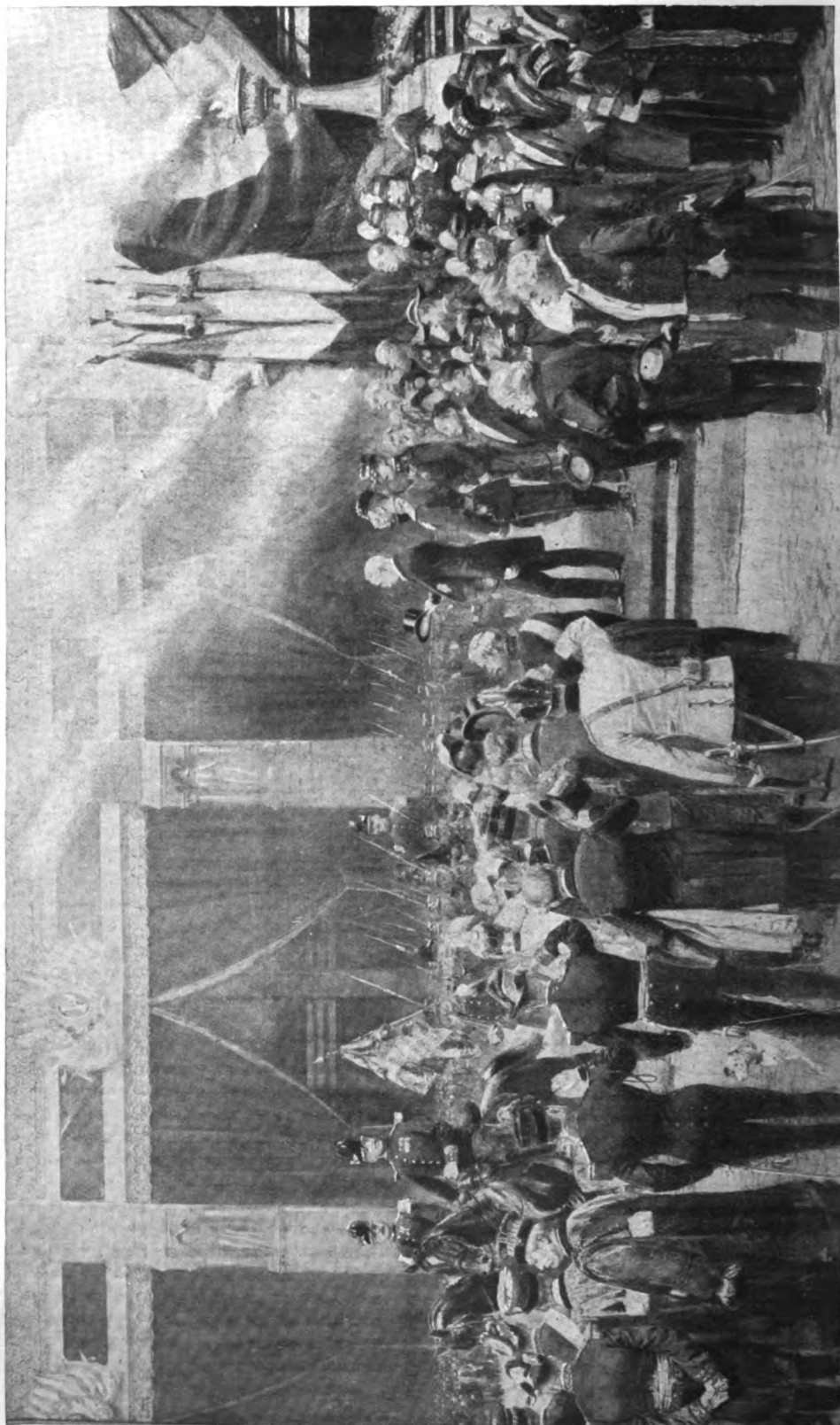

THE PUBLIC FUNERAL OF LOUIS PASTEUR—FROM THE PAINTING BY EDOUARD DETAILLE IN THE MUSÉE DE VERSAILLES

quality. To him we may apply the old saying "He touched nothing that he did not adorn," if we say "elucidate" for adorn. His genius for research, his intuition for the right course to proceed, and the right thing to look for, were simply supreme. A mere list of his successful researches—and all his researches were successful—would take many pages. First he found that there exists a living "microbe"—to use his own term—which acts upon one variety of tartaric acid, but ignores another. The two differ only in one respect that we can discover. They form crystals identical in all respects save that one is "right-handed," and the other "left-handed." Rays of light, of the kind called "polarised," are twisted to right or left respectively by solutions of these varieties of the acid. The crystals and molecules of the two must have the same relation to one another as a right hand to a left, or any asymmetrical object to its image in a mirror. Hence we must think of molecules as *solid* things, with three dimensions in space; and we need a "stereo-chemistry" or "solid-chemistry" accordingly. This great science Pasteur thus founded.

But he was more interested, if possible, in the microbe that showed this singular preference for "right-handed" as against "left-handed" tartaric acid. This, he saw and said, was a case of specific fermentation, caused by a *living organism*. Hence, in due course, the long discussion between Liebig and Pasteur, the older man maintaining that fermentation is a chemical phenomenon, and the younger pointing to the *living* creatures from which it proceeds. We now know that both were right, for we can now extricate, from the living microbes found by Pasteur, the chemical ferments by means of which they work and live—as do all living things.

Pasteur quickly proceeded to show that other fermentations are due to microbes, besides that which proceeds in the salts of tartaric acid. The formation of lactic acid in sour milk is due to a microbe—there are now known to be many—which he found. He showed the same for butyric fermentation, and for the production of "vin-aigre," or vinegar, from wine, by means of the microbe he called the *bacillus aceticus*, and which ferments alcohol, forming acetic acid. The economic value of these researches was incalculable. They taught the wine manufacturers of France how to prevent wine disease. No one guessed then that diseases of somewhat more moment than those of wine might be involved in these researches also.

The silkworm is subject to a disease, which Pasteur was called upon to study. He did so, and found the parasite which preys upon the worm. Thus he saved the silk industry of France, and Huxley pointed out, long ago, that the value of Pasteur's work in such respects, quite apart from any services to man, had more than paid the whole indemnity of the Franco-Prussian War. Beer, like wine, is subject to disease, and Pasteur studied the minute forms of life which are responsible. About this time, also, he joined in the controversy on "spontaneous generation," and showed that, under certain conditions, life does not appear in vessels from which it has been excluded, and in which any pre-existing life has been destroyed by heat. This controversy was supposed to be closed at the time, but Dr. Charlton Bastian, who is still alive, thought otherwise, and is now being justified. The supreme value of Pasteur's researches was that they set him to the great task of seriously, and in detail, studying the behaviour and properties of these microscopic forms of life.

He soon found their responsibility for fermentation in general, and passed from "diseases" of beer and wine, and from disease in the silkworm, to cholera in fowls. He was now approaching his fiftieth year, and was the greatest figure of the age in his own field. Yet, even so, his direct services to man were yet to come. Indeed, they occupy only the last chapter of his life, but it is a last chapter of which the words "Finis coronat opus" may truly be said. The responsibility of microbes for fermentation and putrefaction led Pasteur himself to use antiseptic and aseptic methods in his manipulations and experiments on animals. Lister applied the principle to man and created modern surgery.

Meanwhile Pasteur had proved that a certain microbe causes the terrible disease of animals called anthrax. But this is also a disease of man, and here we have the first discovery that a human disease is due to a microbe. Pasteur proceeded with his researches, and showed how microbes can be modified in virulence, so that animals may be "vaccinated" with weak strains and protected against subsequent infection with virulent strains. This is exactly what Jenner had done for small-pox, without understanding the facts, many years before. Pasteur thus protected the flocks and herds

from anthrax, performing a greater service than when he saved the silk industry.

But, with anthrax, he had reached man. He now tackled hydrophobia, and devised a method of curing this appalling disease by means of inoculation with "attenuated virus." He did not find the microbe of hydrophobia, and we still search for it. It is so minute that the microscope cannot reveal it, and even the ultra-microscope may not suffice.

To discuss adequately the work of Pasteur would be to deal with the monumental sciences of bacteriology, which he founded, and of "public health," and "preventive medicine," which he therefore founded too, in their modern form. Space only avails to say that the French provided him with an Institute in 1886, and there he worked until his death. This Pasteur Institute is now the centre of the world for the study, cure, and prevention of disease, its director being Roux, who helped to give us the antitoxin of diphtheria, and its sub-director, Metchnikoff.

These, and a host of men all over the world, with Lister the Englishman, and Koch the German, at their head, are and were the pupils of Pasteur. He died on September 28, 1895, and his mortal remains lie in a chapel built for the purpose under the Pasteur Institute, where his work is carried on. Louis Pasteur is the greatest physical benefactor of man in recorded time. His work has already changed the conditions of human life and the very face of civilisation, and has enabled mankind to begin the conquest of the "Dark Continent," hitherto held by microscopic parasites and the insects which convey them. Pasteur was a devout Catholic; his favourite motto was "Il faut travailler," and he lived it all his life. His favourite expression in philosophy was that "Tout est miracle;" and if ever there was a miracle anywhere—and he said that all is miracle—it was in his genius, of which unthinkable millions of men and animals and plants have been and will be the beneficiaries, so long as the earth can sustain life. The sun will be very cold ere he is forgotten.

REGINALD C. PUNNETT

The First Professor of the Science of Genetics

Reginald Crundall Punnett was born at Tonbridge in 1875, and was educated at Clifton College and Caius College, Cambridge. He had a distinguished career as a student of biology, and lectured at St. Andrews University from 1899 to 1902. Since that time he has worked in Cambridge, becoming superintendent of the Museum of Zoology in 1909, then succeeding Professor Bateson in the Chair of Biology, which is now extinct, and finally being appointed, in 1912, as first occupant of its successor, the Arthur Balfour Chair of Genetics, founded by an anonymous donor in honour of Mr. Arthur Balfour and the memory of his distinguished brother, Francis Maitland Balfour, a notable student of embryology, who was killed in an accident on the Alps.

Professor Punnett has been associated with Professor Bateson for the last ten years, and is the most conspicuous helper and follower of the present leader of Mendelism, whose term "genetics" receives its first academic recognition in the world in the Chair held by Professor Punnett. The younger student's work has consisted in a number of prolonged and faithful researches designed to test and elucidate the law of Mendel, and the theories of its explanation which have been advanced by Bateson. For this useful and laborious work Professor Punnett was elected a Fellow of the Royal Society in 1912.

Apart from his numerous technical papers, Professor Punnett has written one small but very useful book called "Mendelism." This was first published in 1905, in a very short form, much demanded by readers, and was put into an American edition in 1909 by the wealthy American Socialist, Mr. Gaylord Wilshire, who wrote an introduction justly arguing, among other things, that "Socialism cannot reduce us all to a dead level" if the Mendelian theory is true. Professor Punnett may have been a little surprised at the publication of his book in America in this fashion, but the book deserved and demanded it.

These earlier editions are now somewhat of curiosities. But the whole book has been re-written and much extended. It shows us Professor Punnett as more than a mere breeder and counter of kinds of offspring. He shows us the history and the significance of the subject to which he has given his life; and Eugenists owe much to him for his warning against those of their number who boldly prescribe and conclude without building upon genetic facts, for, as Professor Punnett says, "I feel convinced that if the Eugenist is to achieve anything solid it is upon them that he must primarily build. Little enough material, it is true, exists at present, but that we now see to be largely a question of time and means.

Whatever be the outcome, whatever the form of the structure which is eventually to emerge, we owe it first of all to Mendel that the foundations can be well and truly laid."

Now that Professor Bateson has left Cambridge, the development of the Cambridge School of Genetics, which he founded, is in the hands of his young successor, of whom great things are hoped.

JOHN RAY

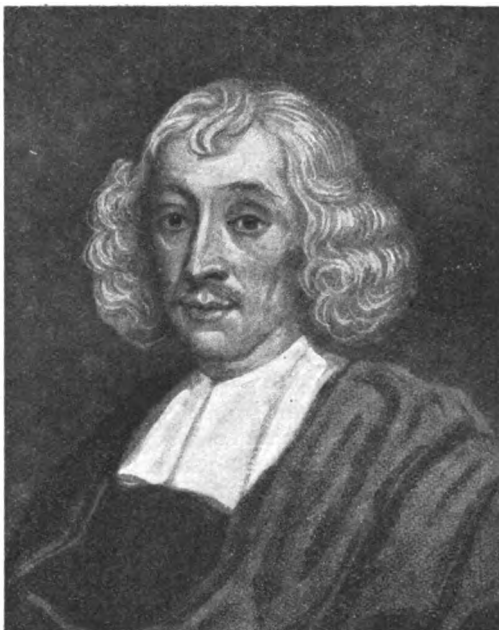
The Philosophy of Order in the Living World

John Ray was born on November 29, 1628, at Black Notley, near Braintree, in Essex, where his father was the blacksmith. The clever boy was sent from Braintree school to Cambridge—the "educational ladder" being not so entirely modern as some people suppose—and there he learnt and taught with great success, preaching his celebrated sermons on "The Wisdom of God in the Creation," and allied subjects, which betrayed the inborn bent of his mind towards natural history.

But in 1661 Ray found that he must become an exile, at any rate from Cambridge, for he could not subscribe to the Act of Uniformity. Soon he went abroad to travel, accompanied by three of his pupils. Upon these travels of his, abroad and at home, he wrote, gaining deserved fame. But his actual collections of animals and plants were more important than his notes. Ray was a born collector and systematiser, and he set himself the task of finding order in the multitudinous forms of the living world. In this respect he was, and always will be one of the founders and pioneers of biological science. Cuvier declared, indeed, that the works of Ray in regard to the animal kingdom formed the basis of zoology as Cuvier himself came to it.

In 1667 Ray was elected to the Royal Society, and much of his most valuable work was thereafter contributed to its transactions. In 1679 he settled down at his native place, and there he lived for the rest of his life. He was a tremendous worker, like very nearly all other famous men. He seems never to have wearied in anything that demanded cataloguing, and collecting data. Though his successors far surpassed his attempts at classification, they and we are immensely indebted to him for his assemblage of facts, and his early attempts towards a natural system. Certainly, but for Ray, we could not have had what we honour the great Linnæus for constructing, a "Natural System" of plants.

Together with his wise and wealthy pupil and patron, Francis Willoughby, Ray published in 1669 their famous discovery of the ascent of the sap in trees. Their interpretation of the facts was doubtless inaccurate in details, but they were the first to find and show that the sap ascends, a discovery which corresponds, in no insignificant degree, to that of the circulation of the blood in the higher animals.

We have seen that Ray was early interested in the relations of science to theology. The facts of natural history were, for him, facts of what Paley, at a later date, was to call natural theology. He looked upon them as Sir Charles Bell was later to look upon the details of anatomy and

JOHN RAY

physiology. Thus his widest fame was earned by such sermons as those referred to, and a later collection of essays, in the same vein, published in 1694, and showing that this aspect of his studies interested him in age as in youth. To him we owe a large number of the astonishing instances of adaptation, such as the structure of the eye, the fitness of the camel's stomach for its work as the ship of the desert, and so forth. For this illustrious student of the living world, such cases—and thousands besides which he studied, in animals and plants, both as regards their main features and the minute details of their structure—were instances of direct and special action on the part of the Creator. The doctrine of

"Special Creation" thus found a supreme champion in John Ray. No one could study the living world as he did without encountering innumerable instances of adaptation, subtle, exquisite, complex beyond belief, and he pointed the moral accordingly.

A later century, not troubling to look too closely at the facts, sought to explain them as all resulting from a chapter of accidents. That view is almost too ridiculous for censure today, and the problem of our time is to restate Ray's interpretation of organic adaptation in a form which can satisfy our deeper and higher notions of Deity, and our knowledge, which he had not, of the fact that species are derived from one another, and were not specially created. If Ray could revisit the glimpses of the moon to day, he would doubtless recognise creative design as immanent in life, and "The Wisdom of God manifested in the works of the Creation" not as an artificer from without, but as a creator from within.

The latter years of Ray's life, at his birthplace, were well spent, though harassed by illness. He did not cease to study and to write. He died on January 17, 1705.

GEORGE JOHN ROMANES
A Great Disciple of Darwin

Among the personal disciples of Charles Darwin there is no more winning figure than that of George John Romanes. In beauty and fineness of character he resembled his beloved master; and though he owed much of his knowledge to personal intercourse with Darwin, he retained his originality of mind, and in the latter part of his life laboured hard to show that natural selection was inadequate fully to explain the origin of species. He believed, of course, in evolution, but he did not agree with the Darwinians in regard to the manner in which life had unfolded in new forms.

Romanes was born on May 20, 1848, at Kingston, Canada. His father was a Scottish clergyman, then acting as professor of Greek at Kingston University, and his mother a Highland lady. In the year in which the boy was born, Professor Romanes came into a considerable fortune, and resigned his position and settled in London. George was not educated, but just allowed to grow up. Any sort of study he did not delight in was given up. He was never punished; he was never even reproved. But far from spoiling under this want of intellectual training, he grew into a singularly gentle and thoughtful lad. His scholarly father regarded him as a dunce, and for a long time he seemed to have no passion for anything but music. But after two years under a tutor he entered Gonville and Caius College, Cambridge, at nineteen, with no knowledge of books and men, and left the university at twenty-five, a trained worker and earnest thinker, already on the way to make a high reputation.

While studying under Sir Michael Foster, he joined the little band of young men that afterwards developed into the famous physiological school of Cambridge. Romanes took up one of the most difficult problems in the study of living forms. He set himself the task of trying to discover in jelly-fishes evidence of the nervous system easily perceived in the higher animals. His successful investigations went to show that nerve tissue, when it first appears on the scene of life, possesses the same fundamental properties as it has in the higher animals. It was the most important piece of work that had been done in any department of the study of animals without a backbone. By it Romanes became famous.

In the meantime, he had attracted the notice of Darwin, on leaving Cambridge, by a letter in "Nature." Darwin sent him a friendly letter, and the acquaintance then made quickly ripened into something that was more than a friendship. Romanes felt for Darwin a love deeper than he had felt for his own father. Inspired by the master, the young man of science took up the problem of the evolution of animal intelligence. At Darwin's suggestion he obtained a young monkey, and kept the creature in his house, and observed its growth of mind. Mrs. Romanes became a mother about the same time, and the baby was also studied by the enthusiastic Darwinian, with a view to comparing the development of its intellect with that of the monkey. If Mrs. Romanes had not vehemently objected, the child and the monkey might have been brought up in the same nursery. Romanes spent much of his time in the Zoological Gardens, and taught Sally, the famous chimpanzee, to count up to five, and pick up and give him any straws up to that number that he asked for. She seldom made a mistake. After many experiments, observations, and studies, Romanes brought out his book on "Mental Evolution in Animals," in which he did much to complete the evidence for the evolutionary view of the origin of man.

By this time, however, he was beginning to grow dissatisfied with the theory of natural selection. On this theory it was supposed that living forms have always

tended to vary slightly from generation to generation, and that, as the slight variations became useful in the terrible struggle for life, new species were gradually built up from them. Romanes thought that this had not always occurred. It seemed to him that a species might change by a sudden, large variation produced by the mysterious play of the inner nature of the organism. Characteristics quite useless in the struggle might be generated by the power of the organism itself. Such useless characteristics are known to exist in many forms of life, and Romanes argued from their existence to the existence of useful variations produced in the same way without the gradual sifting agency of natural selection.

He published a short sketch of his ideas with the object of inviting criticism and help. He reckoned it would take him ten or fifteen years to collect all the evidence and arrange the material in his notebooks. But just as he was entering on the great work of his life he was struck down by paralysis. He then gave up his big scientific work, and dictated notes for the study of the Christian creed in the light of modern science. He came to the conclusion that Darwinism added nothing to the difficulties of faith, but rather that, by bringing more evidence of the unity of Nature and the reign of law, it indicated behind the material universe a mind of a higher nature than ours, yet akin to ours. So he returned to the faith of his fathers a little while before he died, on May 23, 1894.

SIR RONALD ROSS

The Finder of the Malaria Mosquito

Sir Ronald Ross is the son of General Sir C. C. R. Ross, and was born on May 13, 1857. Educated at St. Bartholomew's Hospital, London, he entered in 1881 the Indian Medical Service, and spent seven years wandering from Madras to Bangalore, from Burma to the Andaman Isles. His duties as an Indian Army doctor were not heavy, and he took to writing novels and verses. Suddenly it struck him that the widespread sickness of the people of India was the cause of their bodily and intellectual degradation, and he began to wonder if ancient Greece and ancient Rome had had their strength sapped in the same way. He was struck by the problem of malaria through finding that from half to a quarter of the total sickness in many tropical countries was caused by it, the natives of India being killed or permanently weakened in enormous numbers by the malady. Giving up novel-writing, Ross resolved to devote his life to the conquest of this world-wide plague.

During leave in England in 1889, he studied bacteriology with a view to investigating the cause of the disease. But the laborious researches he made on returning to India did not bring him much nearer his goal. A Frenchman, Laveran, had discovered the malaria parasite in Algeria, in 1880, but the young British surgeon was not well acquainted with Laveran's work. During a visit to England, however, in 1894, he met Sir Patrick Manson, who had gone into the matter, and discussed with Ross the Frenchman's theory that mosquitoes were the carriers of the disease.

When back in India, Ross took up the study of mosquitoes—a practically new ground in science—and found that little was recorded about their structure and habits. In May, 1895, he fed two kinds of gnats on patients suffering from malaria, and discovered the parasites in the blood of the insects. In August, 1896, Mr. Appia, the assistant-surgeon of the Civil Hospital at Bangalore bravely submitted to a dangerous experiment. The two kinds of gnats that Sir Ronald had been studying were allowed to feed on malaria patients, and then bite him a few days later, when the parasites should have developed. There was, however, no result.

His repeated failures convinced Ross that he had been working with the wrong kind of mosquitoes. In April, 1897, he went to an intensely malarious district in the Nilgiri Mountains, to see if he could discover another likely kind. There, for the first time, he saw an anopheline mosquito, which is the true carrier of malaria—the other kind of gnats he first experimented with being responsible for yellow fever, and perhaps other maladies. On August 20 Sir Ronald Ross traced the malaria parasite in two large, dappled-winged mosquitoes, which he had bred from the larva stage, and fed on a case containing infected food. This observation gave him the clue to all that followed, because it indicated the position of the parasite in the mosquito, and also the variety of mosquitoes capable of carrying it. The problem was practically solved, and only details and formal proofs needed to be ascertained.

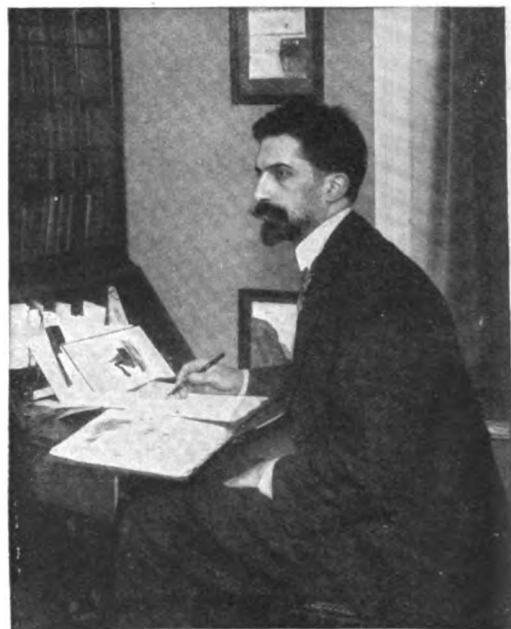
It is not altogether a wise thing for a young officer in the Indian Medical Service to take up scientific research, for if he makes a discovery he becomes the object of jests, sneers, and positive dislike. His

scientific work tells against him in two ways. It looks, in the first place, as though he were trying to win promotion out of his turn, by an unfair display of genius. In the second place, his discoveries disturb the routine of a placid and not very energetic State service. Sir Ronald Ross did not succeed in winning fame and influence in India by one of the greatest discoveries in the history of medicine. No real attempt was made for some years in India to prevent malaria in Calcutta and other important towns by the methods he had worked out. Happily, the world outside India soon recognised the importance of the Indian Medical Officer's discovery, and in 1899 he was appointed director of the newly established School of Tropical Medicine in Liverpool.

In September, 1902, the Suez Canal Company gave him an opportunity of fighting malaria at Ismailia, a town on the canal. The place was swarming with mosquitoes. A mosquito brigade of four men attacked the breeding-places of the insects. Within a year, the cases of malaria were reduced from 2000 to 214. At the present time, endemic malaria has entirely disappeared. In 1902 Sir Ronald Ross was awarded the Nobel Prize for medicine, and he has recently retired from the directorship of the Liverpool School of Tropical Medicine, but he is still working hard at the problems of insect-borne diseases.

CALEB WILLIAMS SALEEBY
A Modern Crusader

Caleb Williams Saleeby, whose share in the making of this work demands the most generous acknowledgment, was born at Worthing an almost incredibly short number of years ago; and he is still, while he is helping to write the last pages of POPULAR SCIENCE, on the hopeful side of thirty-five. But in his case, if in any man's, it may be said that both sides of thirty-five, or both sides of any age, are sure to be hopeful. If Dr. Saleeby was not born an optimist he has reasoned himself into an optimism which survives all the hard disappointments and bitter realities of the world.

It is easy to understand how he came to give up the prospect of a brilliant career as a physician. Graduating first of his year at the University of Edinburgh; at twenty-six he had become a fully qualified physician; and at twenty-eight had won the coveted Fellowship of the Royal Society of Edinburgh. In these same early years he took upon himself the responsibility of the life of resident physician at the Maternity Hospital and Royal Infirmary, Edinburgh. But, though the life of a doctor was naturally congenial to one with so high a conception of the solemnity of life, and though a university career of rare industry and scholarship had placed him on the road to greatness in his chosen path, the essential restraint of a medical career must have been irksome to a man with a passion for crusading in his blood. And so, like a few other distinguished men, Dr. Saleeby burst through the bonds of etiquette laid down by the General Medical Council, gave up his practice, and became, in deed as well as in name, a Crusader for the things in which he earnestly believed. In deed and

CALEB WILLIAMS SALEEBY

in name, we said, for the Saleebys were Crusaders in Palestine a thousand years ago, and the name rises in the home of Christianity and grows out of Christianity itself —*Saleeb*, cross; *bey*, for. Dr. Saleeby, therefore, inherits the traditions of a Christian family in Palestine from the time of the Crusaders. An earnest preacher of the modern gospel of heredity, he is himself a notable example of its truth, for on both sides he comes of a line such as he might have wished to have for his ancestry. His father, upholding the name of his house, set up the first schools in Mount Lebanon, which spread, like cedars of Lebanon, until one writer called them " the most explosive force in the Sultan's dominions." That was

long ago now, and we know the explosion that has taken place in Turkey. What we do not know is the extent to which the founder of the schools of Lebanon may have sown the seed which bore the fruit. On his mother's side, Dr. Saleeby is two generations removed from Dr. Caleb Williams, the Quaker doctor who, nearly sixty years ago, wrote a book trying to prevent criminal lunatics from being hanged in England, and who was for forty years visiting physician to the Retreat, at York, the first humane asylum in the world.

In this line of succession Dr. Saleeby has devoted himself to the task of preaching the science of good living to the people. It is fortunate for the science of eugenics that it has found, in its youth, so ardent and eloquent and vigorous a champion as he. A disciple of Sir Francis Galton, Dr. Saleeby has paid tribute to the memory of that great man by a tireless zeal in carrying on the work that he laid down. More than any other man, Dr. Saleeby stands for eugenics in this country; he it was who first used the word "Eugenist" to describe the adherents of this new school of human welfare; he it is who has written, in these pages the first full, popular statement of the meaning of eugenics; he it is who, at hundreds of meetings in Great Britain and abroad, has preached eugenics without ceasing, until it may be said that the mere mention of eugenics calls up his name, and the mention of his name brings eugenics to our mind. And it may be said here that the eugenics preached by Dr. Saleeby have no relation to the poor thing of which we hear from certain loud critics inside and outside the House of Commons. Those who have read these pages know the things in which Dr. Saleeby believes, the causes to which he gives his life; and the passionate fervour with which he holds his faith.

In this age of specialists Dr. Saleeby has set himself to see life whole, to survey the whole realm of science, and to try to follow its universal movement; and there are few men better informed. Consequently, perhaps, there are few men more sought for on the lecture platform, or at public meetings where social and moral themes are being discussed; and in such questions as infant mortality, the scientific aspect of alcohol, the care of the feeble-minded, and kindred subjects the advocacy of Dr. Saleeby has been an effective force. On the platform, as with his pen, he is picturesque and forceful. One of the most frequent public speakers in Great Britain, as well as one of the busiest writers, he may be said never to have left an audience as he found it. A well-known critic and littérateur declared, after hearing Dr. Saleeby speak, that "I do not know where I have seen a more vivid illustration of the power of speech." It may be said, in brief, that Dr. Saleeby is one of the great popularisers of great ideas; and as there are few public men who speak so often, in so many places, it may be said also that there are few who win so many supporters of good causes.

An unconquerable believer in the triumph of good over bad, with an unquenchable faith in right against might, Dr. Saleeby looks out upon the world and sees it fair. Caring for nothing except as it contributes to Life itself, and to the highest Life, he preaches fearlessly the gospels of John Ruskin and Herbert Spencer and of whatsoever other heroes there be. His books must count a dozen—on evolution, womanhood, parenthood, and other aspects of eugenics. He has lectured at the Royal Institution, read papers before innumerable societies, inspired and promoted conferences, and conducted controversies with characteristic vigour, being, like Shakespeare and Sir Isaac Newton and other mere humans, sometimes right and sometimes wrong. But it is one of the marks of Dr. Saleeby that he is not afraid of the perils of our common humanity; and to such men comes a noble share of our common heritage.

EDWARD ALBERT SCHÄFER

A Great Physiologist and Life-Saver

Edward Albert Schäfer was born in London in 1850, and studied at University College, where he became assistant professor of physiology in 1874. In 1883 he became Jodrell Professor there, and since 1899 he has been Professor of Physiology in the University of Edinburgh, where he exerts an enormous influence upon the medical practice of the present and the next generation. From 1895 to 1900 he was general secretary of the British Association, and in 1912 he was its president. He has received numerous honours at home and abroad, of which one is most unusual, and merits explanation, for in 1909 he received the Distinguished Service Medal of the Royal Life-Saving Society.

This has reference to the most conspicuous piece of research accomplished by Professor Schäfer since he went to Edinburgh. For very many years the accepted method of practising artificial respiration

in the case of the apparently drowned was that known by the name of its inventor, Dr. Sylvester. But the question arose whether a better method might not be devised, and Professor Schäfer, shortly before he left London, was asked by a great medical society to study the question afresh. He did so by means of a long series of researches which involved the drowning of a number of dogs, and an examination of the facts of respiration, and the relative value of various artificial methods for its restoration. Professor Schäfer found that there is one means of "restoring life" which surpasses all those formerly employed. This is the now universally taught and practised "Schäfer method," which has been successfully applied in many cases of immersion, and on account of which its inventor received the medal above referred to. The essence of the method consists in the fact that the subject is placed face *downwards*, and that the chest is gently squeezed by the hands of the operator, who stands or squats astride over him. By this method *one* person, unaided, can do all that is necessary to save life—an all-important advantage in many cases. The lungs and air-passages are automatically emptied of water, sticks, stones, mud, etc.; the tongue cannot fall back and choke the patient; and the interchange of gases, as Professor Schäfer chemically proved in his experiments, is superior to that obtained in any other way. In a word, the Schäfer method has every kind of superiority, and no disadvantages.

The chief part of its inventor's work has lain in quite other directions. He has studied the nervous system, and added much to our knowledge of the nervous tracts which convey the impulses of voluntary motion from the cortex of the brain to the nerve-centres in the spinal cord. This study of the "paths of volition" represents much of Professor Schäfer's special interests in physiology. He is also a notable microscopist, and has written a generally used textbook on the minute anatomy of the tissues, or "histology," as it is technically called. But the most subtle and original part of his work has dealt with the internal chemistry of the body, and, above all, with the production of "internal secretions" by various glands that profoundly influence the activities of other parts of the body. This almost new branch of physiology has been since developed in extraordinary degree by Professors Starling and Bayliss, who carry on Schäfer's work at University College. The understanding of many forms of disease is beginning to flow from the opening of this new door into the *arcana* of the living body.

Professor Schäfer has somehow found time, with all his experimental work, to do a great deal of writing. He is the editor of the "Quarterly Journal of Experimental Physiology," of "Quain's Anatomy," and a foremost writer of textbooks, alike for elementary and advanced students. The most notable of all his writings is the most recent—his Presidential Address to the British Association in Dundee in 1912. Therein Professor Schäfer revealed his views upon the ultimate scientific and philosophical question upon which his own special researches have not borne, and upon which he cannot be regarded as an authority. His address was an able and dogmatic statement of the mechanistic or materialistic theory of life, which was in the ascendant when Professor Schäfer was a young student, and which, in his address, sounded like an echo from those days of more than a generation ago. In some respects this address, indeed, aroused more attention and controversy than almost any delivered from the presidential chair of the British Association since Tyndall's of 1874. The essential statement of the Belfast address and of the Dundee address is the same—that life is a special case of the transformations of matter and energy, and that it can be completely explained by the laws of the material world.

Mind, according to Professor Schäfer, may be ignored in this discussion; and he dogmatically declares that death ends all. The student of today who has some acquaintance with the great contemporary students of the nature of life—to whom Professor Schäfer made but a single contemptuous allusion in passing—must deplore the delivery of this address; but we are bound to be grateful to its author for his many and notable discoveries in physiology, and for his great services to the apparently drowned. If a prophecy may be ventured it is that, in the near future, the students of the nature of life—such as Professor Benjamin Moore—will find in Professor Schäfer's own observations upon the internal chemistry of the body some of the most cogent evidence for the existence of purpose in living things. Indeed, it remains to be seen what Professor Schäfer's last, as distinguished from his latest, opinions on this ultimate question may be.

SIR JAMES YOUNG SIMPSON
The Creator of Painless Surgery

Sir James Young Simpson was born at Bathgate, Linlithgowshire, on June 7, 1811, the youngest of seven sons of a village baker, who with rare heroism submitted cheerfully to much privation to enable the genius of the family to receive a university education. Simpson had a very successful career at Edinburgh, graduated M.D. at twenty-one, was senior president of the Royal Medical Society of Edinburgh at twenty-three, and, five years later, professor of midwifery. He became one of the most famous surgeons of his day; and although, as the result of one of those curious limitations from which many fine minds suffer, he was resolutely opposed to the Lister system of antiseptic surgery, yet his own contributions to surgical methods were of prime importance. Here, however, we are concerned with his inestimably beneficent labours as the introducer into surgery of the use of anæsthetics.

The subject was not new. During the preceding half-century suffering humanity had had the great gift almost within reach. Davy, at the close of the eighteenth century, had given the world the results of his experiments with nitrous oxide, and as nearer our own day Simpson himself prophesied the coming of a time when " by the concentration of electrical and other lights we may render many parts of the body, if not the whole body, sufficiently diaphonous for the inspection of the practised eye of the surgeon "—which seems clearly to forecast the advent of the X-rays—so the youthful Davy had prophesied the use of laughing-gas for annulling pain during surgical operations. In Simpson's day an American dentist had successfully anæsthetised and operated upon a patient suffering from toothache, yet the operating ward of the hospital and the sick-room of the surgeon's patient were still the scene of horrors as hideous as when Palæolithic man trepanned his damaged fellow.

Simpson's biographer has preserved the poignant letter of a patient who recalled the pre-anæsthetic days. " Before the days of anæsthetics a man prepared for an operation like a criminal preparing for execution. He counted the days till the appointed time came. He counted the hours of that day till the appointed hour came. He listened for the echo in the street of the surgeon's carriage. He watched for his pull at the door-bell, for his foot on the stair, for his step in the room, for the production of his dreaded instruments, for his few grave words and his last preparations before beginning. And then he surrendered his liberty, and, revolting at the necessity, submitted to be held or bound, and helplessly gave himself up to the cruel knife."

Simpson heard of the American dentist's success with sulphuric ether, and tried it at once with excellent results in obstetric cases. But he sought a more portable and manageable anæsthetic. He appealed to the scientific chemists of the day for drugs with which he might experiment. The romance of chloroform may be found on page 3678 of this work. The courage of Simpson and his friends in trying these drugs of unknown potency cannot be overestimated. But the world little knows to what lengths the enthusiastic quest of Simpson carried him. Lord Playfair has recorded a dramatic instance. In his autobiography occurs the following startling story of the days when he and Simpson were both in Edinburgh :

" Simpson was constantly experimenting with new anæsthetics. On one occasion he came into my laboratory to ask whether I had any new substance likely to produce anæsthesia. My assistant, Dr. Guthrie, had just prepared a volatile liquid, bromide of ethylene, which I thought worthy of experiment. Simpson, who was brave to rashness in his experiments, wished to try it upon himself in my private room. This I absolutely refused to allow, and declined to give him any of the liquid unless he promised me first to try its effects on rabbits. Two were procured, and under the vapour quickly passed into anæsthesia, coming out of it in due course. Next day Simpson proposed to experiment upon himself and his assistant with the liquid, but the assistant suggested that they should first see how the rabbits had fared. They were both found to be dead! This has always appeared to me to be an excellent argument for experiments on living animals. By the sacrifice of two rabbits the life of the greatest physician of his time had probably been spared."

The story of the troubles by which Simpson was beset in gaining acceptance of his pain-annulling agency for surgical work has already been told. It is unnecessary to emphasise the value of his discovery and labour. Thanks to his merciful revolution, the remotest vital organs of the human organism are now accessible to the surgeon, and operations, rendered safe by the very means which Simpson by a strange irony contemned, are now undertaken every day for

the saving of lives which, prior to his age, must inevitably have been sacrificed. The discoverer of the use of chloroform, as has been shown, extended his activities to many aspects of his calling, and the present generation benefits from the results of his skilful investigations. Created a baronet in 1866, he attained universal fame in his own day, and after his death, which occurred in London on May 6, 1870, was commemorated by a bust in Westminster Abbey, which records that to his "genius and benevolence the world owes the blessings derived from the use of chloroform for the relief of suffering."

JOHN ARTHUR THOMSON

A Great Student of the Meaning of Life

John Arthur Thomson was born in East Lothian on July 8, 1861, and was educated at the University of Edinburgh, and in Germany. When he was twenty-eight, there appeared the volume on "The Evolution of Sex," in which he collaborated with Professor Geddes, his senior by seven years, and which has carried the names of both wherever the science of life is studied. For many years after this date Professor Thomson lectured on Zoology in the School of Medicine in Edinburgh, and his "Outlines of Zoology" was widely used by his students and those within the academic walls. This volume is now in its fifth edition, and maintains the tradition of a zoology that recognises not merely structure, but function, not merely mechanism, but the activity for which the mechanism exists. In 1899 Professor Thomson was appointed to the Chair of Natural History in the University of Aberdeen.

Actual research has not claimed much of Professor Thomson's time, for he has been closely engaged with professorial duties, and his inclinations are those of the critic and philosopher of life. He belongs to the school of those who study what Driesch calls the "philosophy of the organism;" and for every hundred men who can do useful research there is not one who, like Professor Thomson, can appraise the results of research, see their meaning, and indicate the lines of future progress. The biographer's concern in this case is therefore with the numerous and valuable writings of this author, who must be ranked as the leading writer on general biology in this country at the present time. His works may be dealt with in groups.

"The Evolution of Sex" has in it more of Geddes than Thomson, and has been referred to in the biographical notice of the senior author. The "Outlines of Zoology" must be classed with the volume on "Heredity," published in the "Progressive Science Series." It is the recognised compendium and summary of heredity in our language, and indispensable for the student, since it contains so many quotations and references of the first importance.

Professor Thomson was always a cautious author, with much of the Scotsman's traditional "canniness," and he has been severely criticised, as by Professor Punnett, for the fashion in which he seems to give his blessing impartially to various theories of heredity which are more or less incompatible. The criticism is perhaps not wholly unjust, but the consistent temper of this author's mind breeds great confidence in him, and has its advantages for the student. He follows the deep and difficult advice of the late Lord Acton—to understand the case one rejects as thoroughly as that which one accepts—and the fairness of his mind is one of its most valuable qualites. Thus he was one of the very few biologists who extended open hands to Mendelism, and yet, at the same time, he saw and sees how very far even Mendelism is from explaining the origin of progressive variations. No enthusiastic partisan will find full satisfaction in Professor Thomson's writings, but he may find a road towards a wider survey of the truth.

Thus, while Professor Thomson is one of the most useful and searching critics of eugenics, and has forcibly and repeatedly insisted upon the importance of nurture, when one school of eugenists have denied or belittled its importance, he is still able to write such a sentence as this: "There can be no doubt that it would 'pay' the British nation to put aside a million a year for research on eugenics." An author is more than a cold-water critic who can treat a new project thus, and his criticism of it gains incalculably in force thereby for those who are really concerned to learn.

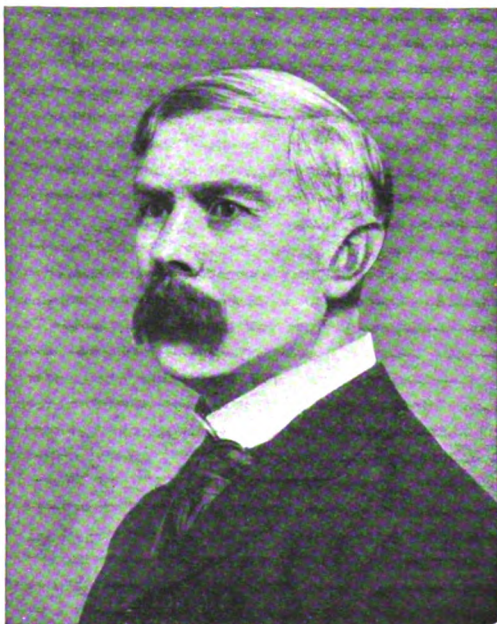
Another group of volumes must rank as more definitely original and constructive, notably, "The Science of Life" and "Darwinism and Human Life," published in 1910, and embodying a series of lectures delivered in South Africa. Lastly, there is the little volume "Evolution," written with Professor Geddes again, and contributed to the Home University Library, part of which Professor Thomson is now engaged in editing. This little book, published as recently as 1911, may be quoted as giving the very essence of Professor

Thomson's teaching in its most mature form. He was one of those biologists who never bowed the knee to Mechanism when it was in its heyday, and so he welcomes Bergson and Driesch, and is prepared to hear their contributions to his science, as he was prepared to welcome the arithmetical ratios of Mendelism a dozen years ago. In this volume all that was true in the teaching of Darwin is recognised and incorporated. The reader will find the spirit and the substance of Darwin here, but the trivialities of "Darwinism" are ignored; and the reader is warned that we must leave to our successors "that rich mastery of the evolution secret we once hoped for." The book is much to be commended, and it forms an intimate biographical note upon the minds of both its authors.

In the more technical discussions of biology, Professor Thomson acknowledges himself a Weismannian, and has done great service for the teachings of Weismann in this country. He has been blamed for the very cautious fashion in which he accepts the Weismannian view that "acquired characters are not transmitted," but those who follow the advance of experimental evolution, especially upon the other side of the Atlantic, are aware that Professor Thomson's caution was abundantly justified, and that the Weismannian view is vastly nearer the truth, when stated as he states it, than in the thoroughgoing—and, in fact, uncritical and inaccurate—form which it assumes in the hands of such hearty advocates as Dr. Archdall Reid.

Professor Thomson's last writing is his "Problems of Sex," which was written with Professor Geddes as a "New Tract for the Times," published for the National Council of Public Morals by Messrs. Cassell. This little "tract" has been, and will be, widely read in this country and the United States. Since its publication he gave in London, late in 1912, a lecture for the National Council, entitled "The Other Side of Heredity," in which the correlative importance and mutual dependence of "Nature" and "nurture" were subtly and profoundly considered. It is to be hoped that this lecture may be published, and that, in years to come, the author may find time for the production of what should be his *magnum opus*, a treatise dealing with the problem of "creative evolution" from the standpoint of the naturalist, and forming a great and fundamental part, together with the work of Bergson from the psychological standpoint, of that future edifice the science of life and mind, as it shall be revealed to life and mind when they have climbed higher yet.

SIR WILLIAM TURNER
A Master of Anatomy

William Turner was born in Lancaster in 1832, and studied medicine in London, at St. Bartholomew's Hospital. He never practised, but at the age of twenty-two began to demonstrate anatomy under the great Goodsir in the University of Edinburgh. In 1867 he succeeded Goodsir in the Chair of Anatomy, at that time already the most famous in the world, and he held it until 1903. During that period of more than a generation, Sir William Turner taught a host of men, from whom Chairs of anatomy throughout the British Empire are now recruited, and he has been the subject of a memorial, presented by his pupils who now teach anatomy throughout the world.

JOHN ARTHUR THOMSON
Photograph by Elliott & Fry

Innumerable honours have fallen to this great master of research and of teaching. He was knighted in 1886, and made K.C.B. in 1901; he is a Knight of the Royal Prussian Order of Merit, and holds honorary degrees from universities throughout the world. From 1898 to 1904 he was President of the General Medical Council. In 1900 he was President of the British Association. When he retired from his Chair, in 1903, he became Principal and Vice-Chancellor of

the University of Edinburgh, which he has since continued to rule with a beneficent rod of iron. He has been President of the Royal Society of Edinburgh since 1908.

Sir William Turner has written no books, but has edited the "Journal of Anatomy and Physiology" for many years, and contributed largely to the "Reports of H.M.S. Challenger." His original researches in anatomy are various, and include much comparative work, as in his studies upon the anatomy of whales. But he has been called "the grand master of placental research," for his famous work upon the anatomy and the functions of the placenta in the mammalian order, of which this organ is the great characteristic. Indeed, Turner and other students have taught us to call all the mammalia, except the very lowest, such as the Australian duck-mole, by a name of their own, the Placentalia, to indicate the fact that in them has been developed the unique organ whereby the young are nourished from the mother's blood before their birth, and so can develop, slowly and securely, that ever-increasing complexity of nervous organisation upon which the highest mammalia, the human species, depend. Much has yet to be learnt about the placenta, its nourishment of the new generation, its double origin from the tissues of the mother and of her child, and its adaptive functions, in the conditions of the modern life of man, as a filter, holding back from the new young life many injurious agents which would otherwise have to be ranked as "racial poisons." But the firm and wide foundations of our present and future knowledge were laid by Sir William Turner in his comparative study of the placenta many years ago. He lives at a great and active age to see the fruits of his labours, not only in science, but in the approaching steps of those who will demand and obtain the protection of expectant motherhood as never yet in history outside the tiny proportion of the human race which has been guided by the hygienic laws of Moses.

RUDOLF VIRCHOW
Founder of Modern Pathology

Rudolf Virchow was born on October 13, 1821, at Schivelbein, in Pomerania, and studied medicine in Berlin. He had a long and distinguished career as a teacher in Würzburg and Berlin, and was for many years Director of the Pathological Institute there. Virchow was a many-sided man, finding time, for instance, to become President of the German Anthropological Society, in which post he did much real work; to investigate lake-dwellings, and to accompany Professor Schliemann to Troy. He wrote various books and papers in connection with these parts of his work. He was also an active politician in the rare, real sense of that word, being for some time Leader of the Opposition in the Reichstag, and foremost opponent of Bismarck. The drainage, the water-supply, many of the hospitals and other advantages of Berlin it owes directly to this great man. Perhaps the greatest hospital in Berlin of today is that which bears his name.

But, above all, Virchow was the founder of the "Cellular Pathology." That is the name of his great work, which was published in 1858. Harvey had taught, for life in general, the famous dogma, "*omne vivum ex ovo*"—that every creature is developed from a pre-existing ovum or egg. Virchow went further, and to him, above all, we owe our knowledge of the fundamental truth that every living cell, of every creature, whether in health or in disease, is derived from a pre-existing cell. This truly epoch-making discovery may be briefly summarised in a Latin formula, "*omnis cellula e cellula*," which is the modern amplification of Harvey's.

Even in his student days Virchow made observations upon the healing of scratches of the eye, which showed him that the new cells, then formed to repair the damage, were derived from the existing cells of the part, and not by a sort of condensation and organisation of the fluids present, as was supposed. To this illustrious student we owe, thanks to the long and final researches upon which he then engaged, our possession of the tremendous piece of knowledge that every cell of a tumour, every cell of the skin or any part of the healthy body in any animal or plant, is the result of division and multiplication on the part of pre-existing cells. The whole of the problem of evolution, and of the origin of life; the whole of the problem of the origin of cancer in the living body; and innumerable problems of biological science, normal and morbid, general and particular, must proceed and be solved upon the basis provided by this discovery of Virchow. We owe to Virchow, as Lord Lister has said, "the true and fertile doctrine that every morbid structure consists of cells which have been derived from pre-existing cells as a progeny," but, while this doctrine constitutes a basis for pathology, it is significant throughout the whole field of biology.

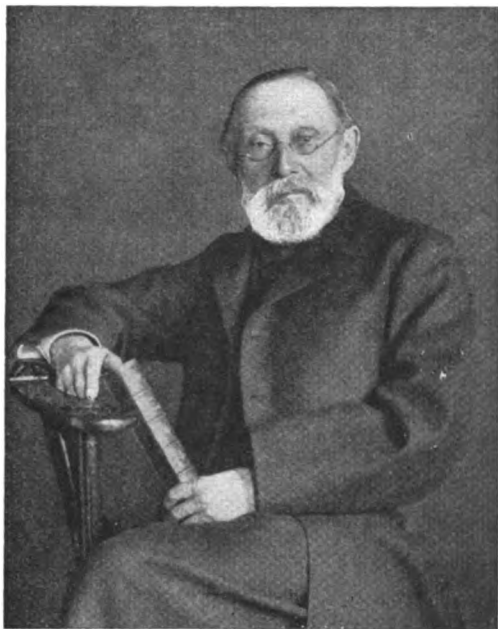
In the nineteenth century many supposed that Virchow had said the last essential word upon pathology. He knew, and we all now know, better. He was a beginner, in the full sense of the word. The "cellular pathology" requires us to study the cell and its chemistry. A new pathology, which is essentially chemical, requires erection upon the basis provided by Virchow; and that is, in fact, the great task upon which our time is engaged.

Virchow was one of those supremely great men who add immensely to human knowledge, and yet are never for a moment deluded into supposing that they know more than they do. This colossus, towering above nearly all the great men of science of the nineteenth century, never yielded an inch of ground to materialism. When Haeckel, in the 'seventies, was desirous of teaching "Darwinism," so-called, in all the schools of Germany, Virchow opposed him, declaring that the cause of evolution had not been discovered, the pretensions of the mechanical school notwithstanding. We look back from today, and may be grateful.

The eightieth birthday of Virchow was celebrated in Berlin with the homage of all the civilised world, learned societies, emperors and kings. On September 5, 1902, he died in Berlin.

ALFRED RUSSEL WALLACE
Joint Discoverer of the "Evolution of Species"

Alfred Russel Wallace was born at Usk, Monmouthshire, on January 8, 1823, the son of a well-meaning but rather hopeless father. Educated at Hertford Grammar School, Wallace drifted into land surveying, which fortunately gave him opportunities of developing an inclination for the observation of natural objects, animate and inanimate. Next he took up school-teaching, and at Leicester had the good fortune to meet his future fellow-traveller, Bates, with whom, in 1848, he set out for what proved a four years' trip to Amazonia—a land which at this very day is being re-explored. Dr. Wallace may well feel "There is a divinity that shapes our ends," for a year before they set out, and long before the world had heard of Darwin, he wrote to Bates, "I begin to feel dissatisfied with a mere collection of beetles and butterflies; little is to be learnt by it. I should like to take some one family to study throughout, principally with a view to the theory of the origin of species. By that means, I am strongly of opinion, some definite results might be arrived at." The stay on the Amazon has already been described in the biography of Bates.

Leaving Bates behind, Wallace returned to England but, through the burning of his ship, lost all his collections, and narrowly escaped with his life. Within a couple of years, however, he was off to the Malay Peninsula, there to dwell for eight years among natives and orang-utans, collecting rare specimens, and seeking to rear infant orangs orphaned by the guns or other weapons of his hunters. Here it was that he pondered the great problems of the rise and development of life which he had been slowly turning in his brain what time Darwin, all unknown to him, was arranging

RUDOLF VIRCHOW

his own ideas on the same subject in readiness for the long delayed "Evolution of Species." Ten years ago Dr. Wallace wrote for the editor of the present publication the romantic history of the simultaneous arrival by Darwin and himself at the great result, and the story cannot be better told than in his own words. It is interesting to remember that he had met Darwin only once—for a few moments in the Insect Room of the British Museum—but they had corresponded in 1854 over a paper which Wallace had written on the skirts of the subject:

"In February, 1858, I was living at Ternate, one of the Moluccas Islands, and was suffering from a sharp attack of intermittent fever, which obliged me to lie

down every afternoon during the cold and subsequent hot fits, which lasted together two or three hours. It was during one of these fits, while I was thinking over the possible mode of origin of new species, that, somehow, my thoughts turned to the 'positive checks' to increase among savages and others described in much detail in the celebrated 'Essay on Population,' by Malthus, a work I had read a dozen years before. These checks—disease, famine, accidents, war, etc.—are what keep down the population, and it suddenly occurred to me that, in the case of wild animals, these checks would act with much more severity, and, as the lower animals all tended to increase more rapidly than man, while their population remained, on the average, constant, there suddenly flashed upon me the idea of the survival of the fittest—that these individuals which every year were removed by these causes—termed collectively the struggle for existence—must, on the average, and in the long run, be inferior to those which managed to survive.

"The more I thought of this the more certain it appeared to be; while the only alternative theory—that those which succumbed to enemies, or want of food, or to disease, drought, or cold, were in every way and always as well constituted as those that survived—seemed to be impossible and unthinkable. So deeply impressed was I with the importance of this theory and of its far-reaching consequences that the very same evening I sketched its outlines, and in the two succeeding evenings wrote it out in full, and sent it by the next post to Mr. Darwin, in the confident expectation that it would be as new and startling a revelation to him as it had been to myself. I asked him, if he thought well of it, to show it to Sir Charles Lyell, but I said nothing about its publication.

"On its receipt Darwin wrote to Lyell as follows, 'Your words have come true with a vengence—that I should be forestalled. . . . I never saw a more striking coincidence; if Wallace had my MS. sketch, written out in 1842, he could not have made a better short abstract! Even his terms now stand as heads of my chapters. . . . So all my originality, whatever it may amount to, will be smashed, though my book, if it will ever have any value, will not be deteriorated, as all the labour consists in the application of the theory.' In his great generosity Darwin wished to have my paper printed at once, and thus give me the priority of publication, but on the advice of his closest scientific friends, Sir Charles Lyell and Sir Joseph Hooker, he allowed an extract from his abstract of 1844 to be presented, jointly with my paper, to the Linnæan Society, where they were read on July 1, 1858, and published in the Society's 'Journal' in the following August."

The story of the noble abnegation of self with which Dr. Wallace stood aside and yielded all the glory of the discovery to his illustrious co-discoverer well harmonises with Darwin's own chivalrous behaviour in the matter. Dr. Wallace's final claim is characteristically modest. "The one great result which I claim for my paper of 1858, is," he says, "that it compelled Darwin to publish his 'Origin of Species' without further delay. The reception of that work, and its effect upon the whole scientific world, prove that it appeared at the right moment; and it is probable that its influence would have been less widespread had it been delayed several years, and had then appeared, as he intended, in several bulky volumes, embodying the whole mass of facts he had collected in its support. Such a work would have appealed to the initiated few only, whereas the smaller volume actually written was read and understood by the educated classes throughout the world." Dr. Wallace, since his return to England in 1862, has been an industrious publicist, a champion of justice and freedom, holding many degrees and distinctions.

AUGUST WEISMANN
A Great Student of Heredity

August Weismann was born at Frankfort on January 17, 1834, his father being a teacher of the classics. After studying medicine at Göttingen, visiting various capitals, and having some practice as a physician, Weismann settled down to research in biology in his early thirties. In 1866 he was appointed Professor of Zoology at Freiburg, where he has lived, learnt, and taught ever since.

His earliest original work was microscopic, but, like many another ardent microscopist, he came near to ruining his eyes, and had to turn to other inquiries—fortunately for science. With true insight, he devoted himself to the central problem of organic evolution—the origin of variations, as to which even Darwin himself had been able to reveal nothing substantial. A long series of papers were published by the young student, and in 1882 they appeared in English, under the title "Studies in the Theory of Descent," with an introduction by Darwin himself.

More than thirty years have passed since the publication of this celebrated volume by Weismann, with its preface by his master, and the rediscovery of Mendel's law has altered the scientific situation profoundly, but we are indebted to Weismann for the impetus, the ideas, and many of the observations which led up to that rediscovery in 1900. His views have undergone some vicissitudes. He declared that a great cause of variations, in all the higher animals and plants, is the fact that the individual is formed by the union of contributions from two parents. There is, indeed, a mixing of elements from both, which Weismann calls amphimixis and regards as a fundamental cause of variations. Later there was developed in this country the statistical or so-called biometric school, which endeavoured to contribute to biological problems. Its students measured the degree of variation in offspring derived from one parent only—by parthenogenesis, or virgin-birth—and found that, in various particulars examined, the range of variation was as great in such cases as where there had been two parents and amphimixis had occurred. It needed a subtler study, made by those who had some knowledge of the nature of the problem involved, to show that what the biometricians observed were "fluctuations" due to varying accidents of *nurture*, and had nothing to do with heredity at all. The rediscovery of Mendel's law proved that Weismann was entirely right, and that in amphimixis is to be found the very seat and cause of, at any rate, a vast number of true variations.

Looking back now, we can thus see that Weismann was on the right lines, and can understand how it came about that the next years of his life were so fruitful, for they witnessed the publication of a series of papers, and, later, of volumes, in which a new theory of heredity is set forth. The English reader of today will find the whole essence of Weismann's teaching in the most famous of these volumes, which was published in the Contemporary Science Series, in 1893, under the title "The Germ-Plasm: A Theory of Heredity." The book would have been very different in many respects had its author seen Mendel's paper, but it was a great piece of work in its day, and must always remain one of the classics of biology.

Darwin had declared for a theory of "pangenesis," according to which the hereditary material to form the next generation is derived from all parts of the parent's body. Weismann offers us a theory which is directly opposed to Darwin's, declaring that the hereditary material is not derived from *any* part of the parent's body, but from a special source, which he called the "germ-plasm," and which is as old as the parent's body, and older. In Weismann's own words, he saw "the necessity for assuming the existence of a special organised and living *hereditary substance*, which in all multicellular organisms, unlike the substance composing the perishable body of the individual, is transmitted from generation to generation. This is the theory of *the continuity of the germ-plasm.*"

No more suggestive and fruitful idea has ever been presented to the minds of biologists, and its services to their science have been incalculable. Today no one believes in "pangenesis," while the theory of "the continuity of the germ-plasm," with some reservations and qualifications, is recognised as expressing a large portion of the truth.

But another question arose in Weismann's mind. If the new individual is not really derived from the body of its parent, will previous changes in the body of the parent affect the constitution of the offspring at all? Here is Weismann's reply: "My conclusions led me to doubt the usually accepted view of the *transmission of variations acquired* by the body; and further research, combined with experiments, tended more and more to strengthen my conviction that in point of fact no such transmission occurs."

Hence arose Weismannism, or "Neo-Darwinism." Darwin himself had believed that the transmission of acquired characters occurs, as would be natural if "pangenesis" were the real method of hereditary transmission. But Weismann and his followers denied this possibility; and hence Darwin's own theory of natural selection, regarded as very important by its author, became *all*-important. No other factor of organic evolution could be admitted, and Weismann wrote his famous paper on "The All-Sufficiency of Natural Selection," which involved him in a very vigorous and interesting controversy with Spencer.

Yet even in this case also the Weismannians have turned out to be far more Weismannian than their master. They have declared that nothing whatever that occurs to organisms can affect the already determined quality of their offspring; and we may admit that in his earlier writings, perhaps, Weismann gave them some excuse for attaching his name to this assertion—

as in the sentence we have quoted above. But Weismann went on learning. He soon discovered that, while his assertion in contravention of "pangenesis" was true, and while, for instance, the enlarged arm of the blacksmith is not transmitted to his children, yet the environment, including nutrition, may act directly upon the germ-plasm within the parental body. This is the mature position of Weismann, and we may now say that we know it to be true; but what he himself, in earlier years, called the "all-sufficiency of natural selection" disappears, once we admit that nurture may affect future parents so as to produce new types of offspring. Such influences may be *adaptive;* and at once we are admitting the views of Lamarck, and "natural selection" recedes into the background!

The student of Weismann may therefore be counselled to avoid and distrust interpreters and apostles of the master who use his name against all the evidence of recent times, regarding the influence of good nurture, or bad nurture, such as the "racial poisons," upon offspring. In the cheap and easily accessible volume which is Weismann's enduring title to fame, the reader will find the master anticipating and admitting the possibility of just such experiments as have been made since his book was written.

A recital of his honours would be wearisome, but he delivered the Romanes Lecture in 1894, was one of the recipients of the Darwin-Wallace medal at the Linnæan Jubilee in 1908, and contributed a masterly essay, "The Selection Theory," to the commemorative volume "Darwin and Modern Science," published at Cambridge in 1909.

GILBERT WHITE
Lover of all Living Beings

Gilbert White was born on July 18, 1720, at Selborne, a little village in Hampshire. He became a fellow of Oriel College, Oxford, but returned to Selborne, and there, or near there, he lived all his life, as a country clergyman.

White had several brothers, all of whom seem to have shared in some degree his passion for prolonged and detailed observation of natural phenomena. His own tastes were satisfied by his native parish, from which he never desired to roam. His mind was of another order than those of the great comparative students of life. But, after many years of observations, which were used and published by other naturalists, White set himself the task of writing "a natural history of my native parish, an annus historico-naturalis, comprising a journal for a whole year, and illustrated with large notes and observations." The result of this intention was the "Natural History of Selborne," which was published in 1789. White had had no scientific training, had not a systematist's mind, and was very casual in his bookmaking. But he brought to his task a deep and beautiful mind, a profound sympathy with living things, and the power to understand them which can never exist apart from such sympathy.

The nineteenth century, while availing itself of many of Gilbert White's observations, found his view of living Nature naïve, simple, unscientific. He did not see and insist upon the "struggle for existence," and the mechanical law of the "survival of the fittest," in the facts of the living world. He saw intelligence, "mutual aid," sympathy, an exquisitely designed order in the plants and animals of Selborne, and candidly and unquestioningly described what he saw. Today we realise that he was not so unscientific, after all. The facts which he observed are facts; animals have intelligence, in some degree, and perhaps plants have also. The living world is informed with mind, as he saw it, after all, though perhaps it needs a mind like White's to see and perceive it. This great and simple man died, a bachelor, on June 26, 1793; and the Selborne Society commemorates him.

SIR ALMROTH EDWARD WRIGHT
A New Defence Against Disease Germs

For the last ten years men of science from all parts of the world have come to London to study in the laboratories of St. Mary's Hospital, Paddington. Working on the discoveries of Pasteur, the director of the laboratories and his staff have found a means of fighting every form of disease produced by vegetable germs that can be seen under a microscope and grown outside the human body. What Pasteur did in regard to rabies is now being done at St. Mary's in regard to bacterial diseases generally by Sir Almroth Edward Wright. Born in 1861, the son of a Yorkshire clergyman famous for his scholarship, Sir Almroth was educated at Dublin University. At twenty-six he was made demonstrator in pathology at Cambridge, and, after teaching physiology at Sydney, returned to England as professor of pathology at Netley.

He took up the study of blood in disease, with a view to finding in the blood of patients some means of testing their strength against a disease, and also discovering the malady from which they were suffering. He made his name by his work on enteric fever—the scourge of soldiers on active service. By his system of preventive vaccination he has produced a remarkable diminution of the deaths from this disease in the British Army in India. Practically all civilised nations are now alive to the value of his preventive method, which saves an army from a malady more deadly than the shrapnel of an enemy.

In the meantime, Sir Almroth Wright has discovered a wonderful power of the blood by means of which he is curing many kinds of diseases, from a common cold to the deadliest form of blood poisoning. His method, which he worked out in 1902, is based on the fact that there is a certain mysterious substance in blood called "opsonin." This opsonin attacks the germs of disease, and so acts on them that they become the food of the white corpuscles of the blood. It is practically certain that in all maladies caused by vegetable germs of disease, a patient recovers or dies according to the strength or weakness of the opsonins in his blood. The opsonic content of the blood is measured by a system worked out by Sir Almroth Wright and his staff.

A drop of blood is taken from a patient's finger, and another drop from the finger of a healthy person. By comparing the time it takes for the fluid part of each blood to act on some suspected disease germs, and counting under a microscope the number of germs devoured by a given number of white corpuscles, the opsonic index of the patient is obtained. If the figure is very low, it shows that the patient is suffering from an attack of the suspected microbe; if the figure is very high, it shows that the microbe in question is not the probable cause of the disease. There are some modifications of this opsonic method in complicated cases of tuberculosis, but generally speaking it is a magnificent instrument in the fight against harmful bacteria.

Sir Almroth Wright has made the further and still more important discovery that it is possible to increase the amount of opsonin in the blood of a patient suffering from an infection of diseased germs that can be seen under a microscope and taken out of the blood and grown in a broth or a jelly. He grows the microbes in this way until he has obtained a considerable quantity of them. He then kills the germs by applying great heat to the vessel in which they are contained, and he floats the dead germs from the top of the jelly into a small bottle of sterilised salt water. By this means a vaccine is made of the dead microbes, and a comparatively small number of them is injected just below the skin of a patient by means of a hypodermic syringe. As the microbes are dead and sterilised, they cannot multiply in the human body, and they quickly become the prey of the white corpuscles, but at the same time the living tissues of the body produce an increased amount of opsonin. This attacks the living microbes of disease in the system of a patient, and the usual result is that the progress of the disease is stopped and the patient recovers.

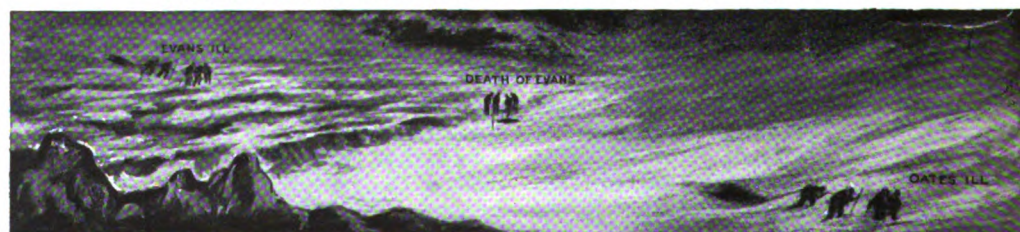
The opsonic index of a patient shows to an experienced physician of the new school what amount of vaccine must be used in order to obtain the best stimulus to the production of the disease-resisting substance in the blood. When Koch made a vaccine of the germs of tuberculosis, he failed to produce a good effect on consumptive patients by vaccinating them. Theoretically, his method was correct, being based upon that which Pasteur employed in the case of rabies. Practically, it was somewhat worse than useless. It was not until Sir Almroth Wright invented his opsonic method, and studied by means of it the effect of Koch's vaccine, that the problem was solved.

Wright discovered that Koch had used much too large doses, and by greatly diminishing the quantity of the dose he has recently obtained some excellent results in tuberculous patients. Moreover, he has found that in some cases of tuberculous disease the patient can be made to cure himself. This is done by carefully regulated exercises. The exercise carries the living disease germ in small quantities to healthy parts of the body. The healthy tissues produce opsonin, and this gets into the blood-stream, and flows to the parts attacked by the disease, and there assists the white corpuscles to devour the tubercle germs. Sir Almroth Wright's vaccine treatment can be extended to every disease of which the germ is known and able to be grown outside the body. When, for instance, a Frenchman, Bordet, discovered the germ of whooping-cough, one of the staff of Sir Almroth Wright's department obtained a vaccine which has proved to be a cure for a severe complaint of children.

THE IMMORTAL STORY OF CAPTAIN SCOTT

The departure from their base of Captain Scott and his companions with dogs, ponies, and provisions, for their dash to the South Pole. The distance to One Ton camp was 100 miles

The difficult ascent of the Beardmore Glacier by a dozen men, seven of whom returned to the base on reaching the vast plateau on which the Pole is situated. Five men made the final dash

The party at the South Pole, which was reached on January, 18, 1912. Here they found a letter from Captain Amundsen, who had arrived a month before. Captain Scott and his companions spent a day making observations

The first disasters on the homeward **journey—**the illness and death of Petty Officer Evans on the **Beardmore Glacier, his** burial at the foot of it, and the illness of Captain Oates

The heroic self-sacrifice of Captain Oates, who walked out into the blizzard to die. The short struggle onward of Captain Scott, Dr. Wilson, and Lieutenant Bowers, and the scene of their death in a tent but eleven miles from One Ton camp

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EXPLORERS

HEINRICH SCHLIEMANN

Discoverer of the Ancient Mediterranean Race

It is not long since we used to think that the Oriental nations had originated the civilisation of the world. The European races were regarded as upstarts who had built upon the work of other peoples. But it is now almost certain that the Mediterranean race, whose territories once stretched from Great Britain to India, invented metals and civilisation. The Asiatics were borrowers, and the Mediterranean is the ancient seat of culture.

Heinrich Schliemann, the pioneer in the exploration of the great achievements of the Mediterranean race, was a clergyman's son, born on January 6, 1822, at Neu Buckow, in Germany. He was well educated in his childhood, and at ten had written an essay in Latin on the Siege of Troy. Family misfortunes put an end to all his hopes of a learned career, and at fourteen he was apprenticed to a small grocer. He had to stand in the shop from early morning till late at night, and could not find a moment to cultivate his mind. Every night he used to pray to God that he might be able to learn Greek, but for five and a half years he swept out his master's shop and scrubbed the floor and served at the counter. When he was nineteen he hurt his chest trying to lift a heavy cask, and had to find lighter work. He tramped to Hamburg, and shipped as a cabin-boy on a vessel bound for Venezuela.

The ship was wrecked off Holland, and the lad was rescued and taken to Amsterdam. He became an errand-boy, and learnt English and French in a year, and so trained his mind that it took him only six weeks to acquire a language. Dutch, Spanish, Italian, and Portuguese were quickly added to his accomplishments. This enabled him to become a corresponding clerk, and by learning Russian he obtained the management of an agency in St. Petersburg.

This happened in 1846, and in the following year he founded a business of his own in the Russian capital, dealing in indigo and tea. When the Crimean War broke out, he became a Government contractor, and more than doubled his capital. By 1858 Schliemann had made sufficient money to devote himself entirely to the fulfilment of his dreams. He had learnt Greek, and was on the point of starting for Greece when a lawsuit recalled him to St. Petersburg, and detained him there for some years. It was not until 1862 that he was able to wind up his business, and set out on his real work in life. He first took a long holiday in Japan and America, and then settled in Paris, and worked at the science of archæology.

In April, 1870, he began his work of excavation, by turning the first sod at Hissarlik, in Asia Minor. Against the views of the leading historians of the day, he had fixed on Hissarlik as the site of ancient Troy. His chief argument was a spade, and by digging down sixteen feet he uncovered the first ancient wall of the most famous fortress in the world. Then the Turkish Government interfered, and eighteen months passed before he was allowed to go on with his work. And the work itself did not seem at first of much importance. The labours

of one hundred and fifty men and an engineer had to be continued till 1873 before the town walls could be traced and the great gate of the stronghold uncovered.

But close to the gate the famous treasure of Troy was found, consisting of numerous golden ornaments and many vessels and weapons of silver and copper. In 1874 Schliemann's book on "Trojan Antiquities" appeared, but it only brought ridicule down upon its author. No scholar would believe that Schliemann had dug up Troy. The excavator also got into trouble with the Turkish Government over the famous treasure, and he was not allowed to go on with his work. But this did not daunt him. He went to Mycenæ, one of the most ancient sites in Greece, and found the graves of the old kings, and dug up such masses of gold as even he, the millionaire, had never before seen on one spot.

Nearly all the ornaments worn by the dead—crowns, breastplates, bracelets, and earrings—were worked in solid gold, and some of the royal tankards weighed four pounds each. These treasures were given to a museum at Athens, where they form one of the most imposing collections in the world. Mr. W. E. Gladstone now came forward as a champion of the German excavator; and by a preface to his second book, "Mycenæ," the English statesman compelled the world to consider the revolution in history that Schliemann had accomplished. In 1879 work was resumed at Troy, and gradually Schliemann was helped by Virchow, Burnouf, and Dörpfeld.

He uncovered the palace of the kings unknown to Homer, and reached a civilisation of Mediterranean origin that had existed long before the earliest of the Greeks appeared in Greece itself. In short, he discovered the high civilisation of the great Mediterranean race. With a remarkable instinct he traced this civilisation to its home in Crete, and began in 1887 to negotiate for the excavation of Cnossos. But his death, at Naples, on December 26, 1890, after an operation, put a sudden end to his magnificent labours, and it has been left to Sir Arthur Evans to attack the problem of Crete, and trace the gradual evolution of the Mediterranean civilisation at Cnossos.

SIR ROBERT HERMANN SCHOMBURGK

Boundary-Maker of British Guiana

When Humboldt was prevented from travelling beyond the little Indian mission village of Esmeralda, on the Orinoco, he left behind him an unknown country three times as large as Spain, in which not a single position had been properly determined. Another German explorer undertook the task of studying this part of our Empire. The work ought to have been done by some bold adventurers of our own race, but in 1835 our country was not remarkable for its scientific enterprise. The work of exploration was largely left to sailors and soldiers—our people generally were absorbed in commercial affairs. In Germany, on the other hand, a new spirit was working, and men of the younger generation were becoming interested in science, and beginning to lay the foundations of the true greatness of modern Germany.

Humboldt's travels especially had a large influence on his countrymen, filling many of them with a new spirit of adventure, tempered and directed by scientific methods. Robert Hermann Schomburgk was among those who felt this influence. Born on June 5, 1804, in Freiburg, the son of a clergyman, he entered a merchant's office, and afterwards started in business for himself, and went to the United States in 1829 with a view to trading there. Apparently he was not very successful in the States, for the next year he settled in the West Indies. Here his passion for the study of natural history came fully into play. Instead of keeping to business matters, he set out in 1831 to survey at his own cost one of the Virgin Isles.

The publication of the results in the Journal of the Royal Geographical Society brought the young merchant-explorer some little fame in a small scientific circle in England, but this circle was composed of men of influence; and, finding that Schomburgk was eager for exploring work, the Geographical Society provided him with funds for an expedition into the hinterland of Guiana. He set out in 1835, and sailed up the Essequibo and its tributary the Rupununi. He kept to the latter stream as long as it could carry his lightest skiff. Then he struck out on foot towards its source, but the rainy season set in, and he fell sick, and had to turn back. He reached Lake Amuki, and ascended the Essequibo to its great falls, which he named King William's Cataract. Fascinated by the strange wonders of the mighty tropical forest, Schomburgk struck out again into the interior as soon as his strength was restored.

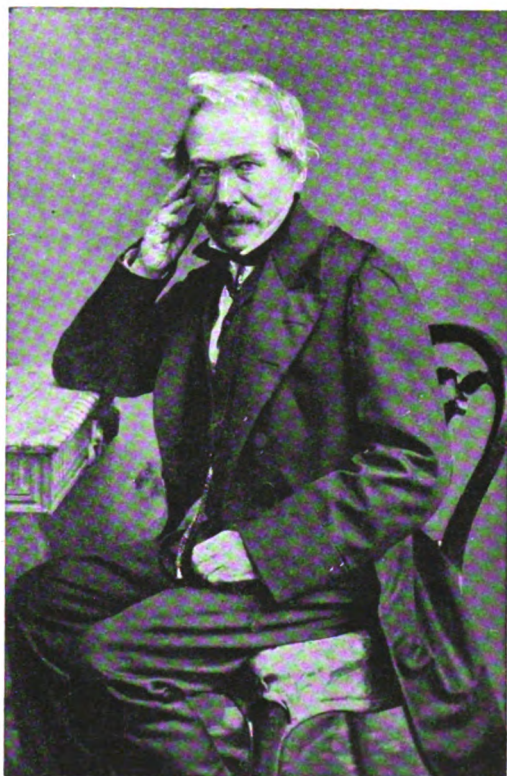
He went up the Corentyn, and at the spot where its source was marked on the map he discovered the river was really an important waterway nine hundred yards

wide. He was stopped at last by a magnificent waterfall forty feet high. This was in 1836; in November of the same year he explored the Berbice in the light skiff he used in his river work. He found his third journey far from dull. There were many rapids swarming with caymans, and in the thickets were numerous boas hungry for prey. Huge fallen trees barred the river in many places, and the rapids increased in number. At every mile the difficulties and the dangers grew greater.

On New Year's Day, 1837, Schomburgk was sorely tempted to turn back. But in the course of the day a wide, smooth stretch of water was gained, and here a remarkable discovery was made. An unusual object on the southern point of the river reach caught the eye of the explorer. He could not form any idea what it was, and hurried his boat towards it. Opposite the object of his curiosity, all his troubles were forgotten. The botanist in him felt well rewarded for the calamities the explorer had suffered. He had discovered the flower-wonder of the world. A gigantic leaf, six feet in diameter, salver-shaped, with a broad rim of a light green colour above and a vivid crimson below, rested on the water. In keeping with the extraordinary leaf was the luxuriant flower, made of many hundreds of petals, passing in alternate tints, from pure white to rose and pink. Thus was discovered the famous Victoria Regias.

Schomburgk was now eager to trace the river to its source, but his crew of Indians were not cheered by the finding of the giant flower. They deserted when the difficulties so increased that two miles a day became quite a fair return for the hardest work they had ever done in their lives. Then the food supplies gave out, so Schomburgk at last turned back, but in September of the same year he struck out in another direction for the sources of the Essequibo.

Travelling among Indians who had never before seen a white man, he traced the river to its rise among the richly forested mountains. In 1838 he went back to Lake Amuku, and from there he walked to a cliff, 1500 feet high, from which rivers fall in wonderful cataracts, and flow away into the Amazon, the Orinoco, and the Essequibo. Leaving this mysterious table-topped mountain, Schomburgk went on through unknown regions to the point reached by Humboldt, and attempted to win to the source of the Orinoco, but the same tribe of murderous savages that had endangered the older explorer menaced the more daring adventurer. Yet he got within sight of the mountains where the river rose, and fixed the source within the narrow limits of under thirty miles.

He was absent from the outposts of civilisation for nearly two years on this journey, and covered more than 3000 miles. In 1841 he surveyed the remarkable delta of the Orinoco; the next year he found the source of the Takutu, a tributary of the Rio Branco. Afterwards he wandered among the wild tribes of the interior, and arrived at one of his earlier goals—the

SIR ROBERT SCHOMBURGK

sources of the Corentyn. By this river he returned to the coast. One of the most curious of his discoveries in British Guiana was the rude picture-writing he traced on rocks for 350,000 square miles. He found the Indians regarded the inscriptions with some awe, but they knew neither the meaning nor the origin of these signs of some vanished civilisation in one of the most savage parts of South America. There were legends of some women warriors connected with the rock-writings, and Schomburgk was told that the Amazons still lived on near the sources of the Corentyn, but

his last expedition took him right through the region of the Indian legends, and, as he expected, he found no trace of the mythical creatures.

Schomburgk settled the boundary of British Guiana, and came to England in the winter of 1844 with some valuable collections, now housed in the British Museum. For his fine services to geography he was awarded the gold medal of the Royal Geographical Society, and knighted by Queen Victoria. Entering the service of the Foreign Office, he was appointed British consul at Haiti, and was empowered to conclude a treaty with the black republic.

In 1857 he crossed the world to Siam, and acted for some years as British consul at Bangkok. He began some exploring work in the interior, and also discussed the project of cutting the isthmus of Kra, and thus shortening the voyage to China and Japan, but his health, undermined by his early labours, gave way, and in 1864 he retired from public service with a pension, and died at Berlin on March 11, 1865.

WILLIAM SCORESBY

The Whaler who Sailed Nearest the North Pole

William Scoresby, the famous father of a famous son, was born at Cropton, in Yorkshire, on May 3, 1760. His parents were poor, and he received little schooling, and at nine he was tending cattle and working about the farm. At nineteen, tiring of his lot as an agricultural labourer, he went to Whitby, and became a sailor. While serving on a stores ship on a voyage to Gibraltar, in 1781, he was captured, and thrown into a Spanish prison, but he escaped, and hid himself on an outward-bound vessel, and returned to Yorkshire.

By this time he had become an excellent navigator, having devoted all his spare time to educating himself and acquiring the arts of seamanship. Whitby was then the centre of the Greenland whale-fishery—an adventurous and rigorous pursuit, in which large profits and great risks obtained. Scoresby started at twenty-five as an ordinary hand, but by his sixth voyage he had risen to the position of second officer of his ship. In 1790 the captain retired, and Scoresby succeeded to the command. His first voyage was not prosperous, and he was so daring in adventuring into the ice that his crew mutinied.

On returning to Whitby he insisted that he must have the appointment of all the hands. So, after some trouble, the owner agreed to this unusual demand, and Scoresby selected a crew who did not fear danger, and pushed into the ice round the Pole in search of whales. He brought back more oil and whalebone than any other man in England, and became the leader of the English whale-fishery. It was reckoned at the time that his average success was four times as great as the ordinary achievement of British whalers. Scoresby rose to the position of a partner in a new ship, the "Resolution." It was in this vessel that he made his famous voyage of 1806, and sailed within 510 miles of the North Pole.

While searching for whales, he entered the ice above Spitzbergen, and found it to be of extraordinary width and strength. Any other man would have turned back. There was a strong ice-blink along the northern horizon, and, brave as his men were, they began to murmur at the foolhardiness of their captain. But Scoresby climbed to the maintopmast head, and discerned a bluish-grey streak below the ice-blink. This was a clear indication that water stretched beyond the ice-pack. It might have been merely a lane or pool of small extent, which would quickly close up, but Scoresby knew more about ice navigation than any man in Europe. He watched his ship, and perceived a slight movement in the lumps of ice around him. He knew this could only arise from a distant swell, and by reason of his extraordinary experience he was able to tell that the movement of the water came from the north, and not from the south.

Thus it was clear to him that there was an open Polar Sea in front of him, and, by a curious method which he had invented, he managed to work his vessel through miles of ice towards the North Pole. He "sallied" his ship by making all his men run in a body from one side of the vessel to the other. This produced a slight rocking motion that gently forced the ice apart and enabled the "Resolution" to sail onwards. Boats were hoisted and lowered to break the ice ahead, and channels were cut with ice-saws, and at last, in latitude 80 deg., an open sea was reached. It was from fifty to sixty miles wide, bounded on the north by the solid Polar ice, and it extended for an unascertained distance from east-north-east to west-south-west. Scoresby sailed across it to the edge of the northern pack, taking several whales on his way, and on May 25, 1806, he reached 81 deg. 30′ N—much nearer to the North Pole than any man before him had ever been.

His magnificent exploit excited much attention, and led to the Government undertaking a national expedition to the Polar regions. Scoresby was much disappointed at not being entrusted with some part in the work of Polar discovery which he inaugurated. As a matter of fact, he built a new ship, especially designed to resist ice-pressure, in the hope of receiving the support of the nation. His son, who had accompanied him at the age of thirteen on the great voyage to the most northernly point then reached by man, continued his work, and explored the coast of Greenland for four hundred miles. William Scoresby jun. was a more scientific observer than the old captain, though he did not get as far North as the whaler. He entered the Church in 1825, and died at Torquay in 1857. His father died in 1829.

ROBERT FALCON SCOTT

The Tragic Hero of the South Pole

Captain Robert Falcon Scott, the tragic hero of the South Pole, was born at Outlands, Devonport, on June 6, 1868. He entered the Navy soon after his thirteenth birthday, and on passing out of the "Britannia" served as midshipman on the Cape Station and elsewhere, and became acting sub-lieutenant in 1887. He received his commission as lieutenant two years later, when he was serving in the "Amphion" on the Pacific Station. After entering the Vernon School-ship in 1891, he specialised in torpedo work, and in 1899 was torpedo lieutenant of the flagship of the Channel Squadron.

Captain Scott had no particular interest in Polar exploration, and it was quite by chance that he became the leader of the "Discovery" expedition. Early in June, 1899, he was walking down Buckingham Palace Road, and saw Sir Clements Markham on the opposite pavement. He crossed over to chat with him, and learnt for the first time that an Antarctic expedition was being formed. He wrote applying for the command of it, and a year afterwards he was appointed and promoted to the rank of commander.

The "Discovery" left London Docks in July, 1901, and returned in 1904, having made more contributions to our knowledge of the Antarctic than had been made for sixty years. Going three hundred miles nearer to the South Pole than Ross had attained, Scott practically solved the problem of reaching the Pole, for he discovered a route to it. Both Shackleton, who accompanied him in his sledge expedition farthest South in 1903, and Amundsen who followed his path, were indebted to Scott's pioneering work.

Besides his great journey over the Ice Barrier, Scott greatly added to geographical science by striking westward through the mountain ranges of South Victoria Land, across the wild and terrible plateau. His work was recognised on his return as one of the most important feats of exploration; and honours were bestowed upon him by both British and foreign geographical societies. He was promoted to the rank of captain in the Royal Navy, and after composing a narrative of the expedition,

ROBERT FALCON SCOTT
Photograph by Thomson

which was published in 1905, he resumed his duties as a naval officer, and obtained a staff appointment in the Admiralty.

But the strange fascination of the bleak and terrible waste of ice around the South Pole worked on his mind and soul. He had been well-nigh frozen to death; he had been frost-bitten; he had been overwhelmed by a blizzard for seven days. He was now honoured by his King and his country, and married, and his feet were firmly set on the path to the highest positions in his profession, yet in his heart he sorrowed for the perils and the agonies of life in the Antarctic. Only the difficulty of raising funds for a new expedition kept him amid the comfort and shelter of civilisation.

His soul yearned for the wild and fierce delight of battling against Nature in her most terrible and overwhelming strength.

In the meantime, Shackleton raised the money for another attack on the South Pole, and Scott waited to learn what his old companion in adventure had achieved. When Shackleton returned with the happy news that the Pole was less than a hundred miles from the point he had attained, Scott yielded to the call that had been sounding in the secret chambers of his heart ever since he returned from the Ice Barrier. He knew he had cleared the path, and he was eager to profit by his own work. With great difficulty he managed to borrow money for his second expedition; and after a Government grant of £20,000 was promised, the explorer got to work on the practical details of his new expedition. The "Terra Nova," a whaling barque of 749 tons, was purchased, and on it Scott and his band of heroes sailed for New Zealand on June 1, 1910.

McMurdo Sound was reached in December, and the main party landed and fixed their headquarters at Cape Evans. Ice prevented the second party from landing at King Edward VII. Land, where Amundsen afterwards came on his dash to the Pole. This second party, under Lieutenant Campbell, wintered in a hut on Victoria Land, and lived on seals. Their adventures and sufferings were heroic, but they managed to win through. A third party was placed on the west side of McMurdo Sound. Scott had taken with him a larger scientific staff than had ever before worked in the Antarctic, his aim being to solve some of the chief problems concerning the character and the history of the high lands around the South Pole. Eleven months were spent in scientific investigations, including the study of the upper air by means of balloon work.

In the meantime the work of laying depots for the march to the Pole had been carried out, and on November 2, 1911, the march was begun. Like Shackleton, Scott did his sledge-work with ponies instead of with dogs. Unfortunately, nearly half of the ponies died before the march begun, and Scott put off for a month his dash to the Pole in order to save his remaining ponies. This was one of the causes of disaster. At first all went well, and the last message received from the expedition told that the Polar party were within one hundred and fifty miles of its goal. Here it was left by the second in command, Commander Evans; and while he was bringing back the news Scott pushed on southward over the glaciers and great plateau.

CAPTAIN SCOTT'S EXPEDITION USING THE DRAG-NET IN SCIENTIFIC RESEARCH IN THE ANTARCTIC

ALPINE DANGERS IN THE ANTARCTIC

A NARROW ESCAPE FROM DEATH IN CAPTAIN SCOTT'S FIRST ANTARCTIC EXPEDITION

With Scott were Dr. E. A. Wilson, the chief of the scientific staff; Captain L. E. G. Oates, of the 6th Dragoons, who looked after the ponies and mules; Lieutenant H. R. Bowers, the commissariat officer of the party; and Petty-Officer Edgar Evans, who had served on Scott's first expedition. They reached the Pole on January 18, 1912, in bitterly unfavourable weather, and the return journey became a dreadful struggle against death. Edgar Evans, an exceptionally strong man and a tried Antarctic traveller, was the first to break down. He was so frostbitten that his comrades had to help him along, and the delay in getting from one depot to another brought them all nearer to death. In February the enormous tract of ice of the Beardmore Glacier was reached. It was the obstacle that had stopped Scott on his first expedition, and it was now much rougher and extremely difficult to travel on. Evans fell, stunning himself and hurting his head, and died on February 17 at the foot of the glacier.

Here the weather, which had all along been bad, suddenly grew much worse. The wind rose to a tempest, and the temperature fell very low, robbing the explorers of their vitality. Captain Oates's feet and hands were badly frost-bitten, and, though he struggled on heroically, bearing intense suffering without complaint, he was at last absolutely unable to travel. On March 16 he went to sleep, hoping that he would not wake, for he saw that his weakness was bringing disaster on his comrades. In the morning it was blowing a blizzard outside the tent. Oates staggered out, saying: "I'm just going outside, and I may be some time." "We knew that Oates was walking to his death," said Scott, "but, though we tried to dissuade him, we knew that it was the act of a brave man and an English gentleman."

Oates was unable to travel, and his companions would not leave him. So he went out into the blizzard in search of the death for which he had been waiting and longing. Captain Scott, Dr. Wilson, and Lieutenant Bowers sadly pushed northward against a high wind that drove the ice crystals like needles into their skin. With bowed heads and aching bodies they fought onward, but the blizzard was so overpowering that they had to creep under the shelter of their tent when only eleven miles from their next depot. They had fuel for one hot meal and food for two days, but the blizzard raged for more than a week. In spite of want of food and want of heat, Scott and his companions lived for four days; and with the coldness of death creeping over him the heroic explorer took out his diary and wrote his memorable account of the tragic expedition:

"Had we lived, I should have had a tale to tell of the hardihood, endurance, and courage of my companions which would have stirred the heart of every Englishman. These rough notes and our dead bodies must tell the tale."

So died Captain Scott and Dr. Wilson and Lieutenant Bowers; and it was not until November, 1912, that their bodies were found. It is hard to find in the entire history of our race so noble an end as theirs. It is one of those rare, high things that hearten and uplift the soul of a whole nation. It inspires generation after generation with courage, chivalry, and self-sacrifice.

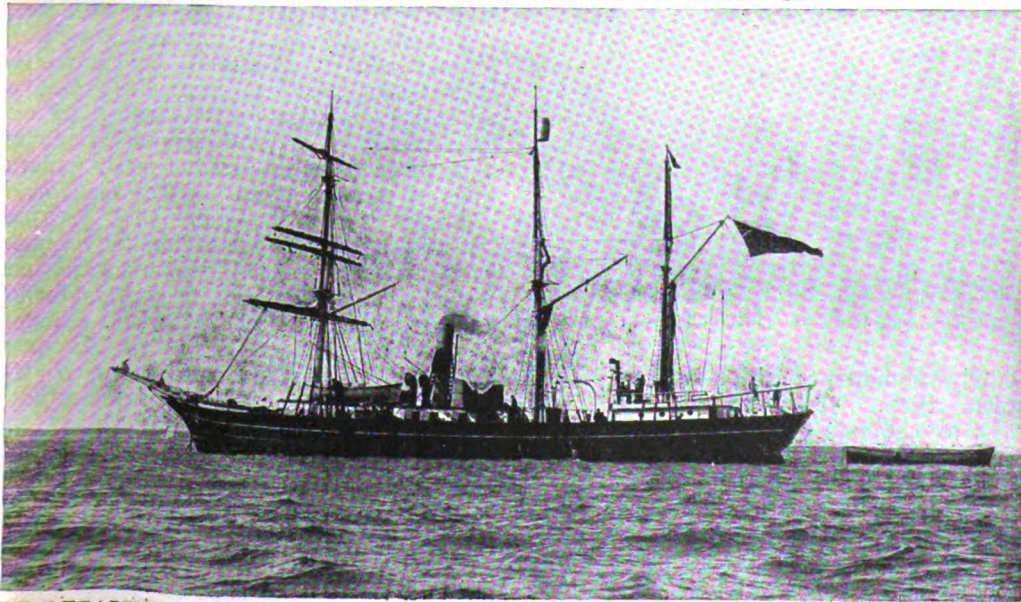
SIR ERNEST HENRY SHACKLETON
Discoverer of the South Magnetic Pole

Sir Ernest Henry Shackleton is the son of a doctor, and was born at Kilkee in 1874, and educated at Dulwich College. He went to sea in the merchant service, and later on entered the Royal Navy Reserve, and won the rank of a lieutenant. Joining the National Antarctic Expedition under Captain Scott, he acted as third lieutenant of the party, and was one of the men who went furthest south in 1902, and saw the bleak, wild upland stretching to the Pole. Unhappily, he was so seriously attacked by scurvy that he was invalided home after the dash towards the Pole. He returned to England convinced that Scott had discovered the path to the southernmost point on the earth; and when the expedition came back he began to plan another voyage of exploration to the southern continent.

With remarkable energy he collected sufficient money to equip the "Nimrod," mortgaging his work for some years in advance in order to raise funds. He sailed from England in January, 1908, and, finding King Edward VII. Land closed to him by a formidable ice-pack, he landed at Ross Island and worked over the region where he had gone with Scott. By the autumn, advance depots of supplies were laid out towards both the Magnetic and Geographic Poles over the Great Barrier. On October 28, 1908, Shackleton with three companions set out for the Pole. They had four sledges and four Manchurian ponies to draw them, and food for ninety-one days.

On November 22 they reached a new land of ice-clad mountains, and found a gap

SOUTHWARD WITH SHACKLETON AND SCOTT

THE "TERRA NOVA" ICEBOUND IN THE ANTARCTIC SEAS

THE DEPARTURE OF THE "NIMROD" WITH LIEUTENANT SHACKLETON'S ANTARCTIC EXPEDITION

leading towards the Pole, but the ice was full of crevasses, and the party had many narrow escapes from death. When the last pony was lost the men were compelled to drag their provisions over the ice. On December 8 they arrived at a great tableland, 7400 feet above the sea, and in this region of eternal snow and ice they found seams of coal in the enclosing mountains. This seemed to show that the land immediately around the South Pole once enjoyed a warm climate. The plateau steadily rose towards the south, and, pressing on with reduced rations, the party reached a height of 10,500 feet on January 6, 1902.

SIR ERNEST SHACKLETON
Photograph by Dinham, Torquay.

Then a terrible blizzard—such as afterwards killed Scott and his companions—fell upon the exploring party, and for nearly sixty hours they were in danger of perishing from cold. When the gale broke, they marched forward for half a day, and found themselves on January 9 within ninety-seven miles of the Pole. They could not go any farther, owing to their short rations and the cold and stormy weather. They were all sick from eating unsuitable food, but safely returned to headquarters.

In the meantime another party from the "Nimrod" had set out to find the Magnetic Pole. After climbing up almost precipitous glaciers, the magnetic expedition reached their goal, but on their return journey found themselves cut off by an open sea in a place where there had been solid ice. They lived on seal and penguin until rescued by the "Nimrod." On his return to England, after a most valuable and adventurous piece of Antarctic exploration, Shackleton received the well-deserved honour of a knighthood in 1909.

CAPTAIN JOHN SMITH
Founder of Anglo-Saxon America

Several attempts were made to plant an English colony in North America by the Elizabethans, but they failed owing mainly to the wild spirit of adventure that animated every man who took part in the expeditions. Dazzled and misled by tales of golden treasure obtained by the Spaniards in Peru and Mexico, the intended settlers aimed at winning a quick fortune rather than at gaining a living by bringing the land into cultivation and trading with the Red Indians. To John Smith, the son of a Lincolnshire farmer, is due most of the credit for the pioneer work of establishing the first and most important English plantation beyond the seas. By saving the colony of Jamestown from extinction at a critical moment in the history of our first successful essay in imperial expansion, he influenced the destinies of many generations of men in many parts of the world.

John Smith, one of the greatest adventurers in the age of high adventure, was born on January 6, 1580, at a farm near Alford, in Lincolnshire. Losing his father at sixteen, he went to France, and enlisted as a soldier under Henry of Navarre. When the King made peace with the Catholic League, John Smith found employment in fighting in Holland for the insurgent Dutchmen. On coming of age, he returned to his native village, and entered into possession of a small property left to him by his father. Most of his time was spent in warlike exercises and in the study of books on the art of war. Repenting of having taken part in the battles between

Christians, he now longed to try his fortune against the Turks—then the terror of Europe. He wandered through France and Italy, and, hearing that the Turks were about to march through Hungary and attack Vienna, he entered the service of Austria. In November, 1602, he was with the army that was broken and scattered in Transylvania by an overwhelming force of Crim Tartars.

Wounded and left on the field, he was taken to Constantinople and sold as a slave to a Mohammedan living in Southern Russia. His master was a brute, and sadly ill-treated him. One day he was threshing corn at one of the farms when the bully struck him, for no reason. Smith swung his threshing-bat, and beat the brains out of the man's head. Hiding the body under the straw, he dressed himself in the clothes of the Mohammedan—who was a man of high Government rank—and fled on a horse into the desert. After riding as hard as he could for some days, he reached a Russian outpost. Kindly welcomed everywhere as an escaped Christian slave, he made his way across Europe, arriving at Leipsic in December, 1603.

There he met an old comrade in arms, and he landed in England, with a fair sum of money, in 1606, and joined in the new attempt made to plant a colony in Northern America. By this time he was apparently a person of some importance, for he was appointed one of the council of thirteen that constituted the American Government of the plantation. On New Year's Day, 1607, two ships and a pinnace, with 143 emigrants aboard, sailed for America. After touching at the West Indies, the expedition arrived in April at James River, in Virginia, and made a settlement at Jamestown. Soon after landing, Smith set out to explore the Chesapeake, and reached the falls where the city of Richmond now stands. Returning to the settlement —that had been attacked by Indians—he directed the erection of the reed-thatched huts, and, gathering a party of axemen, he cut down a large cargo of timber, and sent it to London as the first products of the new colony.

THE MARRIAGE OF CAPTAIN JOHN SMITH WITH POCAHONTAS

But two years after landing the plantation failed. A fire destroyed the new town and a large store of provisions. Sickness broke out, and nearly forty persons died from it, and the settlers became dependent on the Indians for food. Every man—except one—was eager to return to England. That one man was Smith, and, single-handed, he saved the situation. In the summer he was made

ruler of the colony, after two presidents had been deposed for incompetence and injustice. Smith quickly altered the condition of affairs. He convinced the emigrants they were wasting their time seeking for gold and pearls, and he got them to settle down to farming, and make themselves independent for a living, relying neither on the Motherland nor the Indians. Under his direction the town was rebuilt and fortified, and, having put things in order, the captain resumed his explorations.

JOHN SPEKE

In the hope of finding a waterway to the Pacific, he sailed up the Chickahominy, and was captured by Indians and condemned to death, but with magnificent swagger he induced the chief to set him free. He learnt from the natives how to cultivate maize, and sowed forty acres of land in the settlement with the new crop. But the explosion of a bag of gunpowder which he had placed beside him in a boat so burnt and injured him that he became too weak and disabled to govern the colony. So he returned to England, and Lord Delaware went out as governor, with another company of emigrants.

Smith had already explored about 3000 miles of the coast of North America, and he returned to Virginia in 1610, and spent seven years in mapping out New England, from Cape Cod to Penobscot, and searching for new openings for cod-fishers and fur-traders, and surveying sites for settlement. The latter part of his life was largely occupied in writing down the story of his adventures. He died in London in June, 1631, and was buried in St. Sepulchre's Church, Holborn.

JOHN HANNING SPEKE
Discoverer of the Source of the Nile

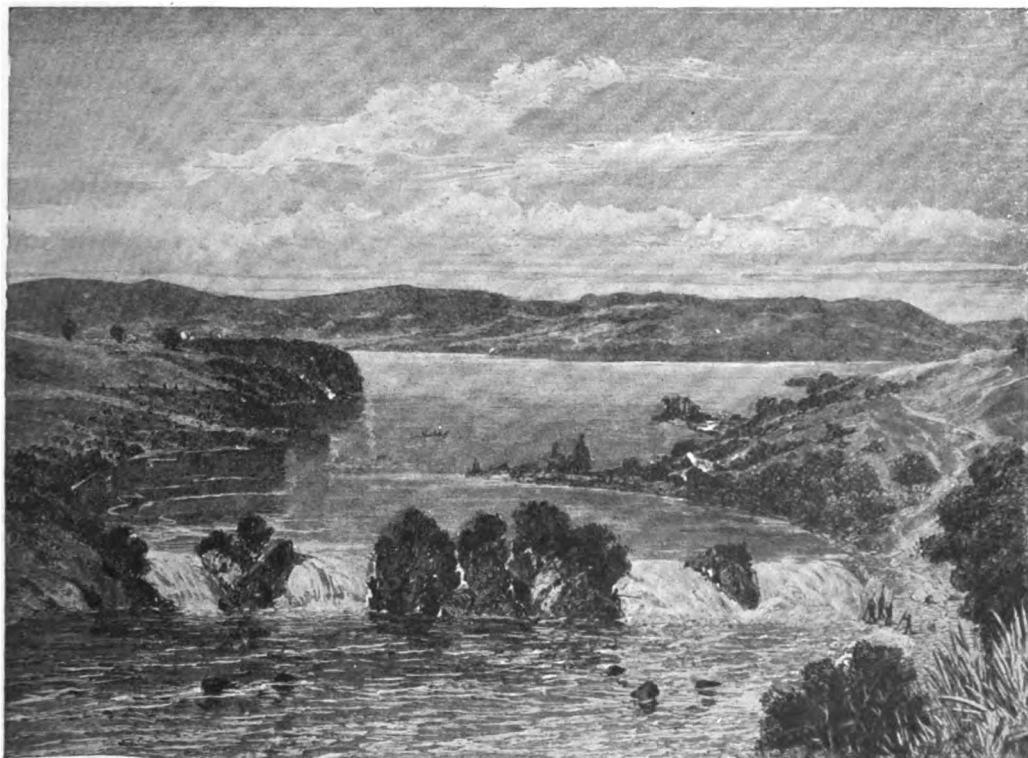
Captain John Hanning Speke, to whom it was given to solve a problem in geography that had puzzled the world for thousands of years, was born at Jordans, Ilminster, Somersetshire, on May 4, 1827. He came of a family of soldiers, and, following in his father's footsteps, was trained from boyhood to a military career. Owing to the influence of the Duke of Wellington, he entered at seventeen the Indian Army, took part in the Sikh War, and by his skill and courage won the rank of lieutenant.

He was a daring sportsman, and, chumming up with another British officer, Captain Grant, went with him in the pursuit of big game. But tigers and elephants were not sufficiently exciting, and when the Sikh War was ended he formed a plan for exploring Central Africa.

He arrived at Aden in the autumn of 1854, and there found that Burton was organising an expedition for the exploration of Somaliland. He joined it, and the expedition was divided into two commands. Burton set out for Harar, the mysterious capital of the country, and Speke tried to explore the north-east of Somaliland.

Unfortunately, he found that the interior was convulsed by war, and he was only able to make a few short excursions to some of the inland tribes. When Burton returned from his more successful journey, the two forces were amalgamated under the command of Burton, but at the coast town of Berberah the party was attacked by Somalis, one British officer was killed, and Speke was wounded and captured. The savages began to torture him, but, with extraordinary strength, Speke burst his bonds and tore down to the coast, where he was met by a rescue party. He soon recovered from his wounds, and, as his

SCENES FROM SPEKE'S AFRICAN TRAVELS

A PARTY ON THE MARCH TO GONDOKORO

THE RIPON FALLS—THE NILE FLOWING OUT OF VICTORIA NYANZA

thirst for adventure was still unslaked, set out with Burton in 1857 from Zanzibar to the goal of his early dreams—Central Africa.

The two explorers were stricken with fever soon after they entered the African jungle, and so weakened were they by malaria that they could not walk. Carried in hammocks, they reached the Usagara mountains, where they recovered their strength, but the tsetse-fly attacked them in the river-courses, and both their men and their cattle suffered terribly from the diseases that the flies introduced into their blood. On November 7, 1857, the expedition arrived at Kazeh, a centre of slave-trading and commerce. Here Speke heard rumours of a great lake to the north; and after he had travelled with Burton to Lake Tanganyika he set out in search of the mysterious lake. On July 30, 1858, he had the glory of discovering the Victoria Nyanza, but he was attacked with terrible pains that stabbed him like a knife, and Burton was also paralysed by some mysterious tropical disease. So they returned in hammocks to Zanzibar, on March 22, 1859.

Speke and Burton disagreed with regard to the importance of the discovery of the Victoria Nyanza. Speke felt sure that he had found the source of the Nile, but Burton, who had been the first to catch a glimpse of Lake Tanganyika, held that this tract of water was the source of the great Egyptian river. The quarrel continued when the two explorers arrived in England, and, at the suggestion of Sir Robert Murchison, a new expedition was fitted out, so that Speke might have the opportunity of exploring the Victoria Nyanza and ascertaining the facts of his theory. By this time there was too much ill-will between Burton and Speke for them to resume their partnership in African exploration. So when Captain Grant volunteered to accompany his old friend, Speke willingly accepted the offer. Some volunteers from the British Army also joined the expedition, and at Zanzibar Speke enlisted a number of native warriors. His first journey through Central Africa had been so impeded and endangered by Arabian slave-traders and hostile tribes interested in the slave trade that he resolved to have a force at hand that would make an attack upon him dangerous to the attackers.

Happily, Speke was a man of remarkable strength of character, and he was able to win his way more by force of character than by force of arms. He managed the savage chieftains he encountered in a diplomatic manner, and they were more anxious to win his help in fighting their enemies than to battle with him. Speke, however, kept clear of all intrigues and wars, and arrived, on January 24, 1861, at his old starting point, Kazeh. Striking northward by himself, he was at last joined by Grant, who had fallen ill. At Kuri the two explorers separated, in order to cover more ground. Speke went by water round the Victoria Nyanza, discovering the Ripon Falls, where the Nile issues from the great lake. Grant, on the other hand, went by land, and rejoined his comrade on the Nile. On February 16, 1863, the Speke and Grant expedition met the expedition led by Baker. Baker was at first terribly disappointed at being anticipated in the discovery of the source of the Nile, but the successful explorers told him of another great lake of which they had heard rumours; and, working on this hint, Baker discovered the Albert Nyanza.

Speke and Grant met with great opposition in England when they announced that they had solved the problem of the source of the Nile. Burton was especially hostile, and his theory was supported by some English and Continental geographers. So keen was the general interest in the dispute that it was arranged that Speke and Burton should thrash the matter out at a meeting of the British Association at Bath in the autumn of 1864. Speke went down to Bath, where an uncle of his had an estate. On September 15 he was out partridge-shooting, and, in climbing over a stone wall, his gun went off and killed him. So it was left to later explorers to confirm his claim to be the first discoverer of the true source of the Nile.

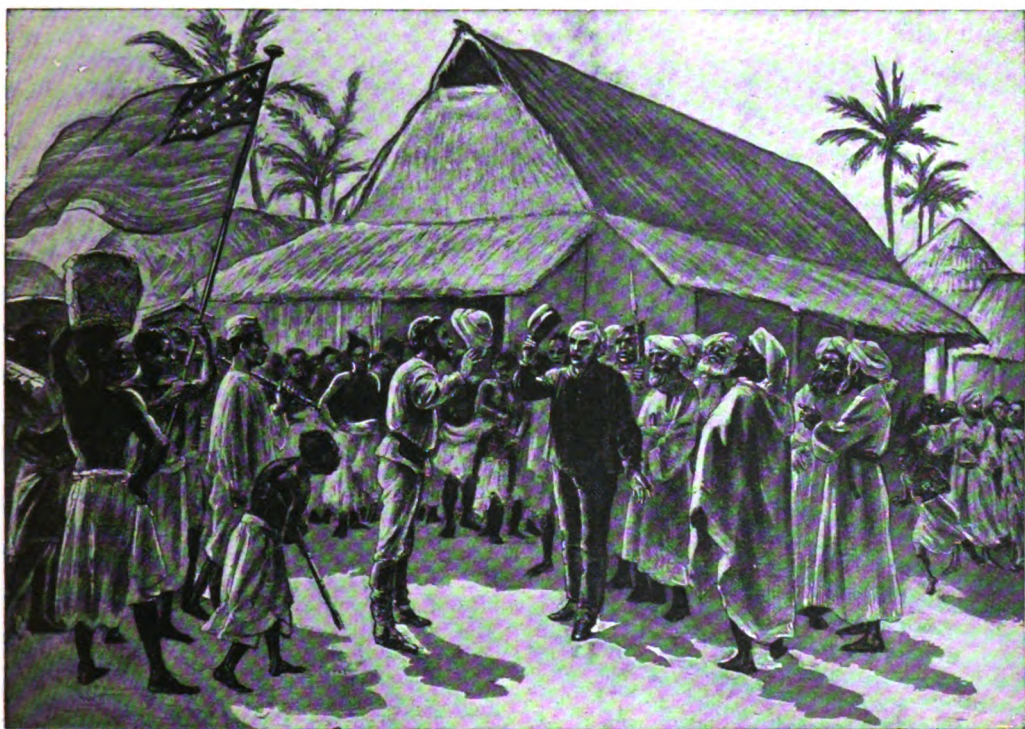
SIR HENRY MORTON STANLEY
Founder of the Congo Free State

Henry Morton Stanley began life in the humblest of ways as John Rowlands. He was born, about 1840, at Denbigh. His father died a few weeks after his birth; his mother went to work in London, and, as his uncles refused to take charge of him, he was sent to the workhouse. There the poor boy was so ill-treated that he never forgave his relatives. Some of them were fairly well-to-do, middle-class people, who carried the Welsh virtue of thrift to an inhuman extreme.

Disowned by his own mother, beaten almost to death by his teacher, and fed on the bread of bitterness, Stanley ran away from the workhouse at sixteen, and, after some adventures in Liverpool, shipped as a

cabin-boy on an American vessel bound for New Orleans. Beaten and knocked about by the skipper, he ran away from the ship, and was helped by a broker of New Orleans, Mr. Stanley. The boy was so grateful that he took the name of his benefactor, and became his adopted son. Unhappily, Mr. Stanley died in 1861, and the wanderer was adrift again.

When the Civil War broke out he enlisted as a Confederate soldier, and was captured at the battle of Shiloh. Discharged in 1862, he returned to Denbigh, but was told by his relatives that he was a disgrace to them, and was asked to leave as quickly as possible. He entered the merchant service, was shipwrecked off Barcelona, and, returning to America, enlisted in the navy. He saw some notable fights, and sent a brilliant description of them to the newspapers, and at the end of the war he became a wandering, adventurous journalist. He had saved enough money to travel in Asia Minor in 1866, but was robbed by a band of Turkomans and thrown into prison. So ended his ambitious scheme for the exploration of Asia.

His letters relating his adventures were welcomed by the newspapers for which he worked, and on returning to the States he obtained a post as special correspondent to a journal at St. Louis, and became a contributor to the "New York Herald." By reason of his adventures in Asia Minor, he was sent out as war correspondent of the "Herald" on the outbreak of war between England and Abyssinia. Through making private arrangements with the chief of the telegraph office at Suez, he was able to send the news of the English victory some weeks before the despatches of other correspondents arrived in London. To this remarkable journalistic coup Stanley owed the extraordinary opportunities that enabled him to become one of the most famous of modern explorers.

THE FAMOUS MEETING BETWEEN STANLEY AND LIVINGSTONE IN DARKEST AFRICA

After acting in 1869 as war correspondent for the "New York Herald" in the Spanish revolution, and travelling to Persia in 1870, he received the most extraordinary commission ever given to a journalist. He was told "to find Livingstone." He set out for East Africa with only sixteen pounds, but, helped by the American consul, raised at Zanzibar sufficient money for his immediate purposes. He started on March 21, 1871, for the interior. Soon the fever attacked him, his horse died, his porters deserted, but he kept on towards Lake Tanganyika, and on his way he heard a rumour of a white

man having been seen some hundreds of miles west of the lake.

Reaching a hill overlooking the famous lake, he saw a caravan, and a tall black man in a long white shirt ran up to him, and said, in English, "Good-morning, sir." He was Susi, the servant of Dr. Livingstone. Stanley's greeting with the lost explorer, "Dr. Livingstone, I presume?" is one of the most famous things in the history of exploration. The two explorers examined the north end of Lake Tanganyaka, and disproved the theory that it was connected with the Albert Nyanza. Livingstone was searching for the Congo, and he would not give up the search. Stanley provided him

SIR HENRY MORTON STANLEY
Photograph by Ellis & Walery

with the stores he needed, and on March 14, 1872, set out on his return journey to civilisation with news that Livingstone was alive and hard at work on exploration.

He received a triumphant welcome in London, and, after following the Ashanti campaign, was given the command of an expedition fitted out by two newspaper proprietors, with the object of completing Livingstone's work. He landed on the West Coast of Africa on November 12, 1874, and, just when most of his men were down with fever, he was attacked, and had to fight a three days' battle before he could reach more friendly tribes.

Arriving at Victoria Nyanza, he settled the dispute between Burton and Speke by circumnavigating the lake. He then went on to Lake Tanganyika, which he also circumnavigated. There remained the grandest task of all, in attempting to settle which Livingstone had sacrificed himself. Was the river known as the Lualaba, which Livingstone had traced for thirteen hundred miles, the Nile, the Niger, or the Congo? Stanley came to the mysterious river after a march of 220 miles. He was attacked by cannibals, but reached the Stanley Falls, and from there he travelled down the Congo in canoes to a point reached by Captain Tuckey from the sea in 1816. On August 9, 1877, he reached Bomba; three days afterwards he stood on the shore of the Atlantic Ocean. On returning to England Stanley endeavoured to induce the British Government to annex and civilise the Congo.

Following out Livingstone's wishes, he wished to introduce Europeans to put down the horrible slave trade carried on by the Arabs, but neither the Government nor the people of Great Britain was interested in Stanley's scheme. So the explorer accepted an offer made by King Leopold of Belgium, and on August 15, 1879, he returned to the Congo to found the Congo Free State. He worked for five and a half years at his task, animated by a high idea, and it was not his fault that the mighty organisation he established was afterwards put to inhuman uses.

After the Fall of Khartoum, Stanley was appointed to lead a relief expedition to Emin Pasha, who, with the only surviving Egyptian force in the Soudan, had sought refuge among the savage tribes north of the Albert Nyanza. Stanley took the Congo route, arriving at Stanley Pool on March 21, 1887. After great suffering from starvation, he reached the Albert Nyanza on December 13, and found that the missing pasha had never been seen there.

Stanley sought for him in another direction, but again failed to find him. Happily, Emin Pasha at last heard rumours of his coming, and wrote appointing a meeting at a southern end of Albert Nyanza. There the reliever and the relieved met towards the end of April, 1888. Emin, however, was not anxious to return to Egypt, from a fear that he might be shelved. He had an abundance of grain and a considerable force. So Stanley set out without him, but Emin's troops revolted and made him a prisoner, and he sent to the English explorer for help. Stanley succoured about a thousand of Emin's people, and conveyed them and the pasha to Zanzibar.

On his way he discovered the Ruwenzori Mountains and the Albert Edward Nyanza. This was the last of Stanley's magnificent exploits. He arrived in London in 1890, and received a splendid greeting, and two years afterwards he again became a British citizen, and then entered Parliament. He died May 9, 1904.

VILHJALMUR STEFANSSON
A Hardy Norseman's Romantic Find

Mr. Vilhjalmur Stefansson is the Canadian-born Scandinavian explorer-ethnologist under whom a new scientific expedition to the Arctic is to set out, under the auspices of the Canadian Government, in June of the present year (1913). Mr. Stefansson has but recently concluded a five years' expedition to the Arctic, in the course of which he has made discoveries of a profoundly interesting character. He has found that the rivers La Roncière and MacFarlane, figured on the maps, are pure creations of the imagination, even as were the mountains (of clouds) that stopped Sir John Ross in his quest of the North-West Passage. The Horton River, which he traced for 400 miles, proves to be deeper than the Coppermine River. Mr. Stefansson shows that not nearly all the ancient errors as to this region have been obliterated. We knew that our old navigators charted bays where open seas lay, and marked down bays as straits, and butted into many an island in the belief that the elusive passage lay that way.

But the result of his five years' sojourn leads Mr. Stefansson to the declaration, made before the members of the Royal Geographical Society during the present year, that a million miles of undiscovered land, now marked as open sea, remain to be mapped and claimed, and he hopes to set up the Union Jack on some of it during the voyage that will begin this year.

The expedition is to be primarily a scientific one, but it has an Imperial aspect, and Mr. Stefansson anticipates the question, "Can results justify the expense, labour, and danger?" by pointing out that in 1867 American statesmen denounced the Secretary of State, who spent one and a quarter millions of money—of public money—for the purchase of Alaska, which, then regarded as "a block of ice," proves to be a land of incalculable riches. But there is a human, as well as an Imperial and commercial, interest in Mr. Stefansson's achievements. He has discovered, in Victoria Island, a race of blonde, European-like Eskimos, of whose existence not a hint had previously been known. Among from 800 to 900 people whom he saw in one district, about 50 per cent. had fair beards, about a dozen had blue eyes, and a number had blonde eyebrows, characteristics to which he, as an expert ethnologist, reminds us, Eskimos have no right. The Eskimo has small, dark eyes, dark, lank hair, "snub" nose, and is distinctly Mongolian in type. But these "blondes" suggest the Norseman, in physical characteristics, in certain of their habits, in the use of a number of words which the explorer believes to be Norse. Until his arrival they had never seen a white man, nor used a rifle or a sulphur match. In doubt as to whether the

VILHJALMUR STEFANSSON
Photograph by Paul Thomson

white men were supernatural or mortal like themselves, they offered them blubber to eat. Supernaturals, they argued, would not take the food; mortals would. The Stefansson party ate, and the mysterious tribesmen were satisfied.

Now, these fair-haired Eskimos, Mr. Stefansson believes, are the degenerate descendants of old Viking colonies by which Greenland and Iceland were peopled, centuries ago. The Black Death and the Hanseatic Wars caused these Arctic islands to be isolated from Europe, and forgotten. In course of time the colonists dispersed to the American mainland, and slowly mixed with the Eskimos, but not completely.

Whereas the average Eskimo can count up to 400, the "blonde" who is more primitive—or degenerate—can count no higher than six. Intellectually, Mr. Stefansson says, they are on a level with what we may imagine the people of Great Britain of ten thousand years ago to have been. Upon his new expedition Mr. Stefansson is to make a closer study of these people; and the world will await with interest the further results of his romantic discovery.

Mr. Stefansson is himself the son of Icelanders, but, his parents removing to Canada, he was born at Winnipeg, in 1878. Accompanying his family to the United States, he graduated at Iowa University, and later became Professor of Anthropology at Harvard. After two trips to Iceland for ethnological purposes he made a remarkable overland journey through Arctic Canada, dwelt with Eskimos, and learned their language. Later, he made an expedition to the North, lasting nearly five years, and was the first man to discover metal—copper—in the Arctic islands.

SIR MARC AUREL STEIN
Spade Exploration in Central Asia

Marc Aurel Stein, the discoverer of a buried civilisation in the great desert of Central Asia, was born at Budapest on November 26, 1862. After studying Oriental languages in Hungary, Austria, and Germany, he entered the service of the British Government of India, and became Principal of the Oriental College at Lahore in 1888. In his spare time he took up the study of works written by early Chinese Buddhists who made pilgrimages to India, and on his holidays he traced their route to the Buddhist shrines in Northern India. By 1899, when he became Principal of Calcutta Madrasah, he had extended his exploration of Indian antiquities to Kashmir and the frontier.

All this work was interesting and valuable in itself, but its chief importance now is that it helped to train Sir Marc for his great achievement. By following in the footsteps of a famous Chinese pilgrim of antiquity, he had found the lines by which the ancient civilisation of India had flowed into China. When he heard that Sven Hedin had discovered ruins of cities amid the seas of sand in the heart of Asia, he resolved to explore the ruins. He had some difficulty in interesting the Indian Government in the affair, but he was at last able, in 1900, to set out for Khotan, on the edge of the western extension of the enormous desert of Gobi. There he found even more than he had expected to find. Seventeen hundred and more years ago streams had run far into the desert, and along the streams great, flourishing towns had been built, with gardens, orchards, and fertile fields spreading round them, and cultivated by a careful system of irrigation. Then, as the streams dried up, huge sand-waves had rolled over trees and houses and canals and temples, preserving almost everything they overwhelmed.

Scarcely anything had decayed, owing to the dryness of the sand. The explorer dug up the writings, furniture, pictures, and art of a forgotten civilisation which proved to be of the highest historic importance. The cities of the desert had been the meeting-place of the civilisations of Europe, India, and China. Here, in the early days of the Roman Empire, the native culture of China had been brought into contact with Greek culture, and the religious influence of Indian Buddhism had spread to the Far East along the same path. Strange writings were discovered that threw light on an almost forgotten Indo-Scythian empire, and a series of magnificent pictures showed that the sand-buried cities had formed the centre from which Indian art and religion spread to China and Japan.

In 1906 Sir Marc Aurel Stein was again able to explore the three hundred miles of sand that hid the lost cities of the desert. He spent about two years in searching and excavating, and studying the treasures he recovered. He went as far as China in quest of documents and pictures, and obtained a collection unparalleled in the story of Asiatic exploration. Caravans loaded with treasures of art and literature were sent by him from the desert, and the boxes safely arrived at the British Museum in London.

Many years will probably pass before all the material is arranged and studied and interpreted. Scholars in all parts of Europe are still busy unfolding the strange story of a vanished and forgotten civilisation. Sir Marc Aurel Stein has reluctantly returned to his ordinary work, and he is now acting as Inspector-General of Education on the North-West Frontier, but he hopes to obtain the leave and the subsidies necessary for continuing his great work in Asiatic exploration. He has fixed on the country around the Oxus as the scene of his future labours, and, if the opportunity is given to him, he hopes to be able to bring to light the vestiges of the earliest North European culture in the lands south of the Caspian Sea.

JOHN McDOUGALL STUART
Across Australia from Sea to Sea

John McDougall Stuart was one of those wandering adventurers who do not wait for opportunities, but make them. Born on September 7, 1815, at Dysart, in Fifeshire, he seemed at first to lack strength of character. The son of an Army captain, he studied for a military career, but gave it up; he then took to a business life, and found it dull; and at twenty-three he sailed to Australia. Still he could not settle to any work: he tried the Government Survey, spent some time in looking after sheep, and, in 1844, joined Captain Sturt's exploring party as draughtsman. Sturt intended to cross the continent from Adelaide, in the south, to the Gulf of Carpentaria, on the north, but he was forced to turn back on account of the sickness of his men.

OTTO NEUMANN SVERDRUP

Stuart had now found the kind of work that suited him. For some time he worked privately, searching for new pasture lands and watered country for great cattle firms. In this way he made useful reconnaissances along the path across Australia he intended to take. He set out with three men from Adelaide on March 2, 1860, and passing to the west of Lake Eyre, which he had previously explored, he travelled over grass country, entering the desert at the McDonald Range. On April 22 he camped in the centre of Australia, where he found plenty of water and pasture for his horses. Soon afterwards he entered a region of thorny scrub, where water was scarce and travel slow, but he would have reached the northern sea if he had not met, a few hundred miles from the coast, a tribe of natives who compelled him to return.

Undaunted, Stuart made another expedition the next year, and came within a hundred miles of the sea. Again the bush stopped him, and food grew so scarce that he was obliged to turn back once more. With remarkable persistency, the explorer made a third attempt in October, 1861. At last success crowned his efforts, and on July 25, 1862, he bathed his hands and face in the waters of the Indian Ocean at Chambers Bay. But the return journey was a difficult and painful operation. Stuart himself was attacked by scurvy, and his men suffered terribly from thirst. They passed creek after creek, and found in each place a dry channel. Stuart was carried into Adelaide in December, weak but triumphant, but he was disappointed when the reward of £10,000 was refused to him. This sum had been offered to the first colonist who crossed the continent from sea to sea, but Stuart only received £2000, as it was alleged that Burke had forestalled him. As a matter of fact, Burke never actually reached the sea, while Stuart completely accomplished the crossing of the great island. He was given a grant of a thousand square miles of land in the interior, but his health was so broken by his continual work of exploration that he never occupied the territory offered to him. He came to England in search of health, but died in London on June 5, 1866.

OTTO NEUMANN SVERDRUP
The Longest Voyage of Arctic Exploration

Otto Neumann Sverdrup, who recently added 100,000 square miles of Arctic land to Norway, was born October 13, 1855, at a farm in Bindalen, in Helgeland. His father owned fields and forests in a rough, hilly country, and the boy became remarkably expert in ski-ing on his native mountains. He went to sea at seventeen, and served for many years in American and Norwegian ships, obtaining his mate's certificate in 1878. Wrecked in a schooner off the West Coast of Scotland, he saved his crew by his coolness and energy, and afterwards commanded both sail and steam ships.

He had, however, given up seafaring and settled down to farming work with his father when Nansen proposed to cross Greenland on skis. He volunteered to

accompany the young explorer, and by reason of his skill as a ski-runner he was selected from the crowd of applicants. The resource and courage he showed in the Greenland adventure endeared him to Nansen; and when the first Norwegian Polar expedition was organised Sverdrup was made captain of the "Fram." The manner in which he sailed this famous ship safely through the ice, from the most northerly point ever attained by a vessel, marked him out for further Polar work.

So, in 1898, he was appointed leader of the second Norwegian Polar expedition. This was a purely scientific undertaking, and no attempt was to be made to reach the Pole. The object was the survey of the vast tracks of unknown land north of Greenland and Canada, and a fine staff of men of science was engaged to study the various aspects of the Arctic regions. The expedition was remarkably successful. Sverdrup left Norway in the "Fram" on June 24, 1898, and returned on September 26, 1902. For four years and three months he worked in the Arctic, with the result that 100,000 square miles of territory were explored and annexed to Norway. Entering the threshold of the unknown region at Jones Sound, Sverdrup made the most extensive additions to Arctic geography. Finding that sledging conditions were unusually favourable. he pursued his exploration to the north and west with fine energy and great success; he marked out the boundary of the main North Polar Basin, and his staff determined the geological structure of the lands around the Pole and collected the plants of the country. He found that musk-oxen and reindeer were abundant, and they provided him with fresh meat in his long sojourn in the region of darkness and ice.

ABEL TASMAN

ABEL JANSZOON TASMAN

The Dutch Discoverer of Tasmania

Holland emerged from the struggle with Spain a great nation. Her new-found sense of freedom flowered out into art, industry, and adventure. Chief among the instruments of Dutch commerce and Dutch power was the famous Company of the Indies that was founded in 1602. This Dutch company wrested from the Portuguese the carrying trade between India, China, and Japan, and in a few years the Dutch were established in Java, Sumatra, Borneo, and the Spice Islands, with Batavia, in Java, as the centre of their commerce and enterprise.

In 1642 the Governor-General of Batavia, Van Diemen, resolved to extend his territories by annexing the Austral continent. This was a mysterious, legendary land which was supposed to lie towards the South Pole. Van Diemen fitted out two ships, and gave the command of the expedition to Abel Janszoon Tasman. Tasman had been born at Lutgegast, in Groningen, in 1602. He had been a sailor from his youth, and at thirty-six he had won the command of an Indian merchantman, and sailed later to Japan, touching at the Bonin Islands, in the North Pacific. Tasman, like most of the adventurers of his age, was somewhat of a buccaneer. He was not averse to enriching himself by pillaging the Spanish possessions that he passed. It was a profitable way of avenging the wrongs done to his country by the Spaniards, and at the Philippines he was afterwards as much feared as Drake had been in Spanish America.

Setting sail from Batavia on August 14, 1642, he passed the isle of Mauritius, and, still keeping a southward course, arrived at a high coast on November 27, which he thought was a part of a great continent. He named the land Van Diemen's Land, in honour of his Governor, but the island is now called Tasmania after its discoverer. He anchored in Fredrik-Hendrik Bay, and ascertained that the country was inhabited, although he could not see a single native.

After following the coast for a little way,

he turned his ship eastward, with the intention of reaching the Solomon Islands. Happily, he mistook his course, and on December 13, 1642, he sighted a mountainous country, and anchored at a spot that he named Assassins' Bay. The natives were tall, with black hair and brownish-yellow faces, and they killed three of his sailors who tried to barter with them. Van Diemen named the country Staaten Land, but it is now better known as New Zealand. On his return voyage to Batavia, where he arrived on June 15, 1643, Tasman discovered the Tonga Isles, the Bismarck Archipelago, and other lands. The chief result of his exploration was to prove that Australia, then known as New Holland, was not attached to the mysterious, mythical Austral continent. In 1664 Tasman sailed to Torres Strait, and explored the Gulf of Carpentaria and the western coast of Australia. He enriched himself by pillaging some Spanish settlements, and died at Batavia in the year 1659.

ARMINIUS VAMBERY
A Wanderer Through Central Asia

Armenius Vambéry, the most venturous of explorers, is the son of a poor Jew of Hungary, who died of cholera soon after the boy was born. Professor Vambéry is himself uncertain about the date of his birth, but it seems to have taken place at St. Georghen in the spring of 1832. The widow and her children got a miserable living by selling leeches. For the most part they lived on bits of black bread begged or bartered from gipsies. Early in his life the now famous traveller was smitten with a disease that permanently crippled him. Jeered at by Christians, and often ill-treated by them, the pale, starving, lame Jewish boy fought for an education with the energy that he fought for food. His father had been a religious student who vainly struggled to obtain the position of a rabbi, and the boy inherited his intellectual capacity, but lost his early religious beliefs.

His great gift was for languages. When he was eleven, he set out with a crutch under his arm and a small bundle on his back, and walked to a neighbouring town, where he obtained a position as tutor and bootblack at the house of an innkeeper.

He afterwards studied in a Catholic school under some monks, and, after mastering the chief European languages, took up the study of Turkish, Arabic, and Persian. He was always half starved, and sometimes wholly starving, but now and then he obtained a position as tutor in some well-to-do family where food was abundant. But he loved books more than bread and meat; and a professor whom he met was so struck by his passion for learning that he lent him many expensive books and manuscripts in Asiatic tongues which Vambery could not afford to buy.

In 1857 the wandering scholar set out for Constantinople, with the idea of pursuing his Oriental studies in the Orient. He entered Constantinople with no soles to his boots and no money whatever in his pockets.

ARMINIUS VAMBÉRY

At the end of a few years he was a friend of some of the highest Turkish Ministers of State, having won his way into Turkish society as a tutor of foreign languages, with a knowledge of Turkish and Arabic that amazed the Turks themselves. Had he wished, he could have settled in Constantinople and acquired wealth in the service of the Turkish Government, but he still loved knowledge more than money. The only use he made of his friendship with the Turkish Minister was to obtain letters of recommendation to the Shah of Persia.

Then, arrayed as a Turk, he set out with a small trading caravan for Teheran. Unfortunately for him, the Persians differ from Western Mohammedans in matters of religion. The strife between them is more fierce than that between Catholics and Protestants two or three hundred years ago. Vambéry, indeed, says that he was, as a Turk, treated by the Persians in much the same way as he had been treated as a Jewish boy by the Christian Hungarians.

At Teheran disputations were organised by the Persian priests for the conversion of the Turkish scholar—no one ever discovering that "Reshid Effendi" was a European. After exploring Southern Persia, Vambéry was sufficiently "converted" to adopt the dress of a wandering monk, or dervish, and, with some Tartar pilgrims on their way back from Mecca to Central Asia, he set out for Bokhara.

After travelling for two months with the pilgrims, he learnt so well their ways of life and their manner of speech that he was indistinguishable from them. Among the natives of the Turkoman territory he passed for a holy pilgrim, and was treated with great reverence, but on the journey to Khiva he met an Afghan who had fought against the British, and this man was so struck by the European cast of his features that he denounced him as a spy. Happily, the explorer's fellow-pilgrims regarded him as somewhat of a magician, and consulted him when they were passing through perilous deserts. He was offered the command of some thousands of Turkoman raiders for an attack upon the Persian frontier. Thinking it was a test, he did not suddenly reject the offer, but pretended to consider it carefully, and slowly come to the conclusion that it would not be successful.

So, without great peril, he arrived at Herat, collecting on his way specimens of Asiatic languages then unknown to Europe. In audiences with khans and emirs, full of suspicion against the strange dervish, he bore himself so well that sometimes gifts were made to him. He returned by caravan to Persia in the spring of 1864, and made his way through Constantinople to Hungary, arriving at Pest in May. But though the newspapers of Europe had long accounts of his adventures, his own people received him coldly and indifferently. So he went on to London, where he was welcomed by the Royal Geographical Society and received by Lord Palmerston.

His knowledge of the politics and currents of feeling in Central Asia made him a man of importance. He received in our country that which he had been longing to receive—the fame of an adventurous and scientific explorer. His studies of hitherto unknown languages were best appreciated in Germany, but the man himself was warmed and heartened by his social and popular success in England. He became a devoted friend to our country, and laboured ever afterwards to advance our interests in Asia and among the Mohammedan world generally. Returning home, he was made Professor of Oriental Languages at Pest, where his life has passed in study, interrupted by holiday trips to England.

AMERIGO VESPUCCI

The Man After Whom America is Named

Amerigo Vespucci was born at Florence on March 9, 1451, the son of a notary, and the nephew of Friar Giorgio Antonio Vespucci, the learned doctor who marches, eloquent and powerful, through the life-story of Savonarola. To him Vespucci owed his education and his opportunity to equip himself in astronomy and geography. Vespucci helped to fit out the ships for the second expedition of Columbus in 1493, and claims himself to have set sail in May, 1497, and, in June of the same year, to have reached what should be Cape Honduras; to have sailed thence up the coast of Yucatan, along the coast of the Gulf of Mexico, to Florida, and then to have compassed a further extensive coastal exploration northward before turning eastward to the Bermudas, and so home to Spain, arriving in October, 1498. Now, this account would make him reach the American mainland before either Columbus or Cabot.

In Fiske's painstaking "Discovery of America," Vespucci's account is carefully set forth—and endorsed. Other authorities, weighing its many improbabilities, its obvious inaccuracies and contradictions, refuse to accept the story. Of the later voyages of Vespucci to America, of his discovery of All Saints' Bay, on the coast of Brazil, and of his exploring south as far as Cape Frio, there is not the least doubt. There remains, however, the gravest suspicion as to the story of that first misty voyage. But, whatever the date of his arrival, Vespucci realised, as Columbus never did, that this fresh-found continent was not the opposite extremity of the land which Da Gama had reached by sailing by the African route to the east. In the course of a letter written to Lorenzo de Medici in 1503, Vespucci says: "I have formerly

written to you at sufficient length about my return from those new countries which, in the ships and at the expense and command of the most gracious King of Portugal, we have sought and found. It is proper to call them a new world."

Within a year the letter was translated into Latin and published, in pamphlet form, bearing the title, "The New World." A copy reached the hand of Martin Waldeemüller, professor of cosmography at St. Dié University, in Lorraine. He at once incorporated the letter in a "Cosmographic Introduction" for his new edition of Ptolemy's works. Having previously treated the world as consisting of three continental divisions, he now added to his introduction: "But now . . . another fourth part has been discovered by Amerigo Vespucci—as will appear in what follows—wherefore I do not see what is rightly to prevent us from calling it Amerigé, or America." The suggestion for a name was thus given to the world five years before Vespucci died, and a year after the grave had closed over Columbus.

The name thus suggested was, of course, adopted. It was given by a man of no account, in honour of a man of still less account, and for ever we hail Columbia by a title which ignores the valiant soul who had the courage first to seek her. True, Columbus did not know that he had found a New World. He thought to the end that he had found a part of ancient Asia. Vespucci was more right than he, but his name ought never to have been bestowed upon the land. "Cabotia" should have been the designation if its natural appellation, Columbia, could not be applied. Vespucci, who after his voyages settled down as a naturalised Spaniard, and became chief pilot of the kingdom, was a first-rate explorer, with, it is to be feared, a fatally elastic conscience in respect of that dubious first voyage. He died at Seville on February 22, 1512.

JAMES WEDDELL
Explorations of an Antarctic Sealer

After Captain Cook had vainly sought for the Antarctic continent, the waters around the South Polar regions were for many years visited only by British and American seal-fishers. The sealers made discoveries of importance, but for the most part they kept their knowledge secret. They wanted no rivals in the places they found by chance or adventure. When, for instance, William Smith, an English whaling captain, announced his discovery, in 1819, of the South Shetland Islands, the British and American seal-hunters descended in force on the new-found lands, and worked their way to the South Orkney Isles.

Three years afterwards, James Weddell, another sealing captain, excited the attention of Europe, and aroused a new enthusiasm for Polar exploration in our country, by finding the Weddell Sea, and sailing 240 miles nearer to the South Pole than Cook had gone. This remarkable achievement was done in the ordinary way of work, but the man who did it was one of the most skilful navigators of his era. The son of a London working upholsterer, Weddell was born on August 24, 1787. The death of the

AMERIGO VESPUCCI

father brought the family to misery soon after the boy's birth. There was little money for his education, and he was soon set to earn his own living on a coal-boat.

Like Scoresby, whose Arctic exploit he equalled in the stranger Antarctic seas, Weddell had that natural talent for learning that no system of instruction can supply. By instinct he sought for the intellectual tools he needed, and improved his mind in his spare time. Having acquired the arts of seamanship and navigation, he sailed to the West Indies at sixteen, and worked for some time in voyages across the Atlantic. He became a young man with an uncommon strength of character and strength of body, and he ended a dispute with his captain by knocking him down.

The angry skipper handed Weddell, on

a charge of insubordination and mutiny, to the captain of H.M.S. "Rainbow." But this intended act of punishment was converted by the hardy and skilful young sailorman into a means of promotion. He proved himself an alert and able seaman, continually improving his talents by study, and in 1810 he was made master of the "Firefly," and later master of the "Hope." But the overthrow of Napoleon, and the restoration of the peace of Europe, put an end to his naval career, and he was retired on half pay. On this he lived for three years, but he found at last an outlet for his energies in a voyage of adventure to the South Seas. He was given the command of a brig, the "Jane," of Leith, and sent on a sealing trip to the recently discovered South Shetland Islands. There he was so successful that on his return he was able to buy a share in the "Jane."

On September 17, 1822, he set out on the voyage that made him famous. He left the Downs with two vessels—the "Jane," of 160 tons, and the "Beaufoy," a cutter of 65 tons. Steering straight for the South Orkney Isles, he made an accurate survey of the coasts. He then shaped his course for the South Sandwich Isles, and ascertained that no land was to be found between the two island groups.

Turning south, Weddell crossed the Antarctic Circle, and soon sighted ice. His ships were hemmed in by the ice-pack and menaced by huge icebergs, but, though blinded by fogs and snowstorms, he held to his course with dogged persistence, groping his way through the grinding floes. Suddenly, in latitude 72° 38', S, he entered a clear, sunny sea. It was the depth of winter, but the weather was mild, flocks of birds hovered above the brig and cutter, and large schools of whales sported in the wake of the vessels. Weddell sailed eagerly on, hoping to sight the Antarctic continent. But when he was in latitude 74° 15', or about 945 miles from the South Pole, the wind changed, and he felt compelled to take advantage of it and sail back. The season was late, his provisions were short, and he had to pass homeward through 100 miles of sea strewn with ice, with long nights and heavy fogs. He had reached the most southernly point attained by man, and discovered a new kind of seal, known as the Weddell seal.

On the return voyage he was prevented by the ice-pack from reaching the sealing islands, and had to sail north without a cargo. His two ships were separated by a storm, but met again in New Georgia, after a perilous voyage of 1200 miles among the ice. Weddell made for Tierra del Fuego, and examined some of the coast, with a view to helping navigators, and studied the strangely low natives. It seems as though Weddell's fame as an explorer was purchased at his cost as a shipowner. His loss of a cargo of sealskins must have made his voyage one of considerable expense, for some years afterwards, he returned to the position of a skipper of other men's ships and he died a poor man, in Norfolk Street Strand, on September 9, 1834.

SIR HUGH WILLOUGHBY
Pioneer of the North-West Passage

Sir Hugh Willoughby, the first of the great gentlemen adventurers, was born somewhere about the beginning of the sixteenth century. He came of a great fighting stock, and his family was landowners of ancient power in Nottingham. Sir Hugh was a handsome man of great height and strength. He fought against the Scots in 1544, and was knighted for his bravery at Leith by the Duke of Somerset. Four years afterwards he was made Captain of Lowther Castle, but the fall of the Duke of Somerset put an end to his military career. So he came to London in search of employment, and met Sebastian Cabot. On the advice of Cabot, three ships were fitted out for the search for the North-West Passage to China, and Willoughby was appointed commander of the expedition. He had no knowledge of seamanship, but some first-rate pilots were engaged, and Willoughby was made leader by reason of his skill in war and his talent for governing men.

The expedition left Greenwich on May 11, 1553, and all the Court came to see it off. The little fleet was obliged to put in at Harwich to get fresh provisions, as their victuals went bad. It was not until June 23 that the ships left the coast of England, and steered for the Lofoten Isles, where they arrived on July 27. As they were making for Vardohuus, a gale arose, and the three ships were scattered. Two met again the next day, sailed into the White Sea, and landed near a Russian castle. There Richard Chancellor went to Moscow, at the invitation of Czar Ivan, and established trade relations between England and Russia. On his return to London, the Muscovy Company was formed, with great profit to the enterprising merchants who had sent out the exploring expedition.

In the meantime, Sir Hugh Willoughby,

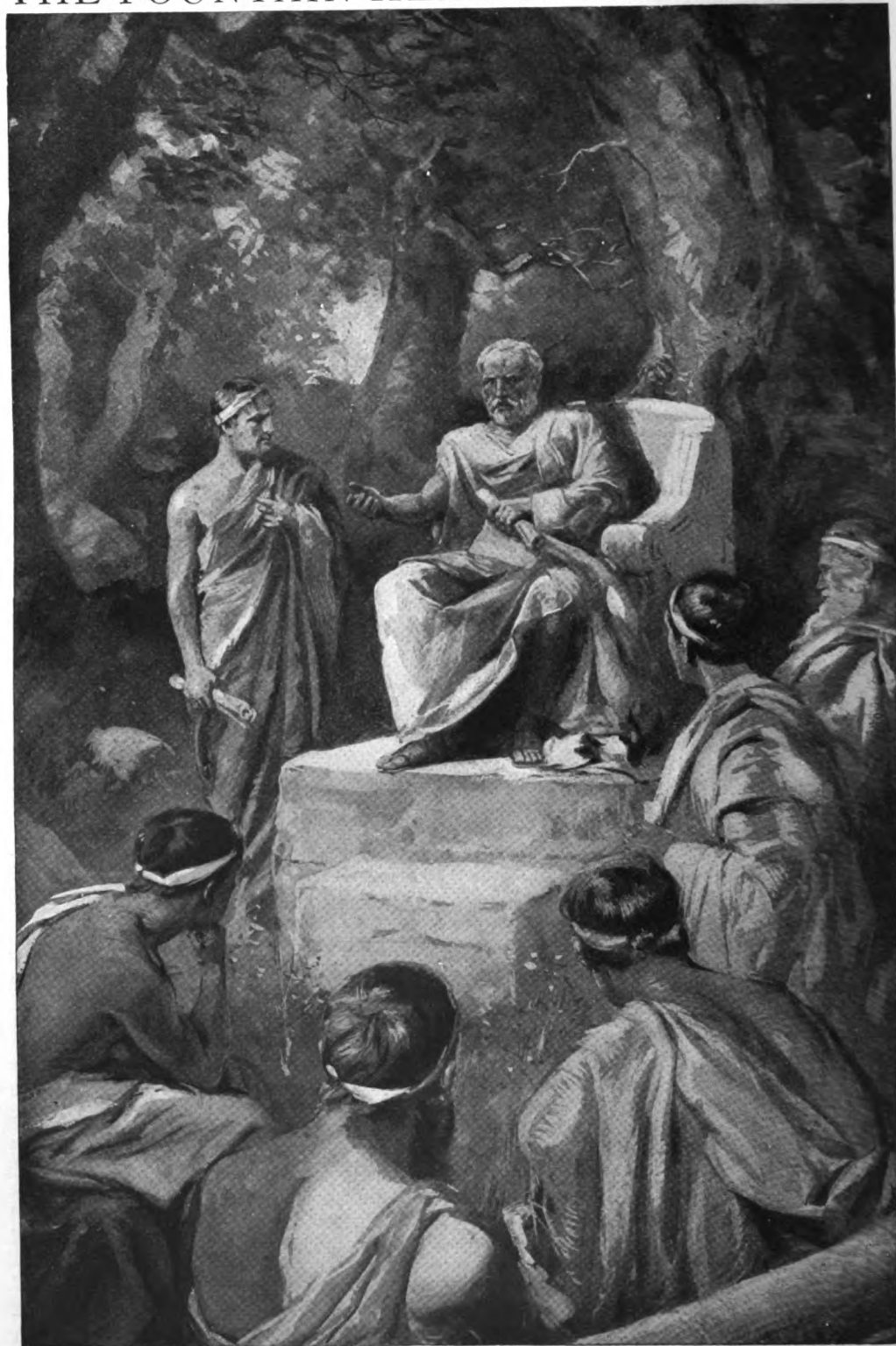
ignorant of navigation but wild with the spirit of adventure, let his ship go with the wind, and on August 14 he sighted the icy, desolate coast of Novaya Zemlya. He was the first man from Europe to penetrate thus far into the Arctic wilderness, and he paid for his achievement with his life and the lives of his crew, for, turning back, he arrived on September 18, 1553, at Arzina Harbour, where Lapland joins Russia, and there the storms held his ship, and, after a terrible struggle against starvation, he perished with his men in January, 1554.

FRANCIS XAVIER
Missionary Explorer in the Far East

Francis Xavier was the son of Juan de Jasso, a privy councillor to King John of Navarre. The boy was born at the castle of Xavier, near Pampeluna, on April 7, 1506. Xavier was his mother's name, and, by a curious Spanish custom, he was only known by it, instead of by his father's name. Francis intended to follow his father's career, and went at eighteen to the University of Paris. At twenty-four he was appointed a lecturer in philosophy at the Collège Beauvais. The brilliance of his mind attracted Ignatius Loyola, who had come to Paris to win disciples, with a view to forming a new order for a mission to the Holy Land. He had much trouble in gaining over Xavier, but when the young scholar adopted the new religious discipline he proved to be second only to the founder of the Jesuit Order in qualities of mind and soul.

Francis was one of the seven men who took the famous vow at Montmartre in 1534, and thus originated the Society of Jesus. He went with Loyola to Rome, and spent three years trying to create a religious revival at Bologna University. Then King John of Portugal asked for missionaries to the Far East, and Francis, taking the place of two men who had fallen ill at the last moment, set out in the spring of 1541 on the great work of his life. He arrived at Goa, in India, in May, 1542, and for two years worked among the fishermen of Cape Comorin. But he found that the lives led by the Portuguese adventurers in India were disastrous to the cause of Christianity. They needed conversion more than any native, but he could not uplift "the dregs of humanity," as he called the Portuguese. Though he was extraordinarily successful as a missionary at Travancore, this was due more to the political policy of the native prince than to any sincere conversion of his people. The wholesale conversion was simply a bid for Portuguese support against the power of the Mohammedan rulers. Xavier, tired of the intrigues and disorders of life around him, and sighing for new horizons, sailed to the Banda Islands, the Spice Islands, and Ceylon. In the last country he converted the King of Kandy and many of his people, but in this second part of his career in the Orient he worked more as an explorer than as a missionary. He was searching for a field of work where, in his own words, Europe could not overturn what he built up. This he found in Japan, where he landed in 1549, accompanied by a young Japanese whom he had taught at Goa. He visited Kagosima, Hirado, and Kioto, and founded a mission that flourished for a hundred years.

FRANCIS XAVIER

Some of the chiefs of the great Japanese clans were interested in the strange religion from Europe, but Xavier could find no way of arousing their enthusiasm. He saw that China was then the source of Japanese culture, and that in the commerce of ideas China was all-powerful. So it struck him that it would be best to devote his whole energies to preaching the Gospel in China, for this would have the effect of deeply influencing the Japanese mission, while at the same time it spread Christianity among the Chinese themselves. It was a fine, statesmanlike idea, but the Portuguese put difficulties in the way of its execution; and, worn out in mind and body, Xavier died at San-chain, near Canton, on December 22, 1552. His body was interred at Goa, and he was canonised in 1622.

PLATO TEACHING HIS FOLLOWERS IN THE "GROVES OF ACADEME," AT ATHENS

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F. W. NIETZSCHE

The Conceiver of the Superman

Friedrich Wilhelm Nietzsche was born at Röcken, Saxony, on October 15, 1844, and had an education of the usual type at Bonn and Leipsic. In his earlier years he wrote with great distinction and power upon various æsthetic questions, such as Greek tragedy. He also fulminated against Wagner, whose works he had at first admired. Then there followed the works which have made him famous, and have recently been translated largely into English. These range from the year 1878 up to the year 1896, when Nietzsche published "Thus Spake Zarathustra."

During the last decade of his life Nietzsche was insane, and there are many insane characteristics in "Zarathustra," as in its predecessors. These have been mercilessly, if not extravagantly, pointed out by Dr. Max Nordau, in his well-known book "Degeneration." Nevertheless, Nietzsche was a writer of unquestioned genius, as anyone may observe from the collections of his sayings, many of which were put into the mouth of "Zarathustra."

Nietzsche was much taken with the theory of Darwinism. He saw the great side of the record of organic evolution, and honour is due to him on that account. If man has ascended from the lower animals, we must look for a higher being than man, who is to succeed him. This being Nietzsche called the "Superman," and the name and the idea have now passed into the common currency of thought. But, unfortunately, Nietzsche argued from a notion of Darwinism which Darwin would have been the first to repudiate. He ignored the "survival value" of pity, maternal instinct, co-operation, and altruism, and assumed that the struggle for existence depends wholly upon an individualistic competition between individuals. To any naturalist the whole conception is simply ludicrous. But from this Nietzsche went on to declare that pity and sympathy and the whole Christian system are "the morality of slaves." They must be abolished by the coming of the "Superman," who is to be the incarnation of power, pitiless, insatiable, all-conquering.

A certain school of Eugenists, so-called, have drawn freely upon these ideas, and seek to have natural selection, which they misunderstand and limit wholly to the egoistic impulses, regarded as the creative force of the future. But serious thinkers have long ago shown the unscientific basis of Nietzsche's theories, and the overwhelming evidence of madness in his writing. He was particularly violent in his hatred and contempt of women. He died at Weimar, on August 25, 1900; and we can only surmise what would have been the fruits of his magnificent natural genius if, by a tragic stroke of fortune, disease had not perverted and finally ruined it.

NOVALIS

The Most Ideal of Idealists

Friedrich von Hardenberg is not a name known to philosophy or literature, but "Novalis" is, thanks in a large degree to the partiality for him shown by Thomas Carlyle. Novalis was the pseudonym chosen by Von Hardenberg, and it has entirely superseded his own name. He was born near Mansfeld, in Prussian Saxony, on May 2, 1772, his father, who had been a soldier, being director of the local salt-works. The family was earnestly religious,

and the boy carried on the family tradition in that respect. His education before he attended Jena University was almost private. From Jena he went to Liepsic, and finished his formal studies at Wittenberg. At Jena he studied under Fichte, and became acquainted with Schlegel, while at Wittenberg he was much influenced by Schiller. Besides metaphysics he studied the physical sciences, mathematics, and history. It is to Tieck, who only met him in later years, that the world is chiefly indebted for what it knows of his life and work.

Novalis began practical life as an official in the business of which his father was a director, and the same year fell deeply in love with a beautiful girl who, three years afterwards, died. About four years later, on March 25, 1801, he himself died of consumption. His writings belong largely to the time that was coloured by his early sorrow. Later, when he went to Freiberg to study mineralogy under Werner, he had recovered from his romance sufficiently to become affianced to another maid, but his breakdown in health prevented the marriage.

Tieck gives a striking description of the personal appearance of his friend, in whom all the distinguished men of his circle saw a thinker of fine but subtle genius: "Tall, slender, of noble proportions, his hazel eye clear and glancing, his look cheerful and kind, he presented a figure that might be called beautiful. His frank bearing made him a universal favourite. Without vanity, far from every affectation, he was a genuine, true man—the purest and loveliest embodiment of a high, immortal spirit."

Novalis was a mystic. He held that the highest truths cannot be reached by logic, but came to men through intuition and sympathy. Only his poems "Hymns of the Night" and "Sacred Songs" are complete. His prose works are all fragments, and fragments that can only be interpreted by the intuition in which Novalis believed. "Naturally a deep, religious, contemplative spirit," says Carlyle, "purified also by harsh affliction, and familiar in the sanctuary of sorrow, he comes before us as the most ideal of all idealists. In sober belief he feels himself encompassed by the Godhead; feels in every thought that 'in Him he lives and moves and has his being.'"

"For him," says Tieck, "it had become the most natural disposition to regard the commonest and meanest as a wonder, and the strange, the supernatural, as something common; man's everyday life lay round him like a wondrous fable, and those regions which the most dream of, or doubt of, as a thing distant and incomprehensible, were for him a beloved home."

Such a man, of course, had no system of thought, the more so as he died before the age of thirty. Had he lived, he would never have systematised his wizard probings of the realms of the spirit, but he had rare flashes of insight, and by these he lives. "Philosophy can bake no bread, but she can procure for us God, Freedom, Immortality." "Philosophy is properly home-sickness—the wish to be everywhere at home." "Every beloved object is the centre of a paradise." "The fresh gaze of a child is richer in significance than the forecasting of the most indubitable seer." Of Novalis it may be said, as was said of Fichte—his piercing thought, like lightning, appears but for a moment, but it kindles a fire which burns for ever.

WILLIAM PALEY

A Great Master of Argument

William Paley, Archdeacon of Carlisle, a shrewd philosopher on religious lines, was born at Peterborough in July, 1743. His father was a minor canon at the time of the son's birth, but became headmaster of the grammar school of his native parish, Giggleswick, shortly afterwards. As a boy, one of Paley's biographers says, "He mingled intellectual activity with corporeal indolence." He was an awkward lad, with no play, though he had that liking for mechanical contrivances which often goes with hearty play. When he entered Christ's College, Cambridge, at the age of fifteen, he rode there with his father, and proved his want of the activity natural to boys by falling off his horse seven times during the journey. The account he gives of it is: "My father, on hearing a thump, would turn his head half aside and say, 'Take care of thy money, lad.'"

At Cambridge he spent two years, "happily but unprofitably." The words are his own. He was brought to his senses by one of his companions, who, after a late night, appeared at his bedside in the morning, and declared that if Paley persisted in his indolence he would renounce his society. "I could do nothing, probably, if I were to try," said the warning visitor, "and I can afford the life I lead; you could do everything, and cannot afford the life you lead." Paley took the hint, studied diligently, and became Senior Wrangler.

On leaving Cambridge he taught Latin

for three years at a school in Greenwich. In 1766 he was elected a Fellow of his college, and later became a tutor, his subject being moral philosophy. With him as a fellow-tutor was Mr. Law, son of the Master of Peterhouse. Law senior became Bishop of Carlisle, and at once acted as patron to Paley, and made him his chaplain. As a friendly biographer quaintly says: "After providing for his son, Bishop Law conferred upon Paley the best benefices he had to bestow." This patronage culminated in 1782 in the Archdeaconship of Carlisle; and in 1785 Paley was made Chancellor of the diocese. In 1787 "he lost his venerable friend and patron." Later he received recognition in the form of pluralities from the Bishops of London, Lincoln, and Durham, till he was a wealthy man, but he never became a bishop himself—a remarkable omission, if we remember the spade-work he did in defence of religion, but not remarkable when one realises the texture of the archdeacon's mind and character. Paley was very logical, very clever in argument, sensible, humorous, practical, adaptable, but not conspicuous in "the beauty of holiness." He was a forger of weapons, but not an inspirer of fighting-men.

His four works, besides sermons, were "Principles of Moral and Political Philosophy," published in 1785; "Horæ Paulinæ," 1790; "View of the Evidences of Christianity," 1794; and "Natural Theology; or, Evidences of the Existence and Attributes of the Deity," 1802. He died at Bishop Wearmouth, where he was rector, on May 25, 1805.

As a writer, Paley was, above all, clear and simple. He never penned a sentence that was obscure to the average intelligence. And he had the power of building up a case by sheer number and concentration of his arguments. But he was always an advocate. It was well that the Church should have certain things proved, so he set himself the task of collecting and arranging the proofs. His plan, as he confided to his readers, was to "extract what I could from my own stores and reflections in the first place; to put down that, and after to consult upon each subject such readings as fell in my way. I make no pretensions to perfect originality, but I claim to be something more than a mere compiler." His "Moral Philosophy" is a frankly utilitarian argument—an argument for prudently making the best of both worlds—and it contains an abundance of sound sense. The "Horæ Paulinæ" is an argument for the natural production of the New Testament narratives, as shown by their undesigned coincidences. If the Scriptures had been false, he contended with great force, they would have been written quite differently. The "Evidences of Christianity" was written to meet the special doubts of the period, and is now very much out of date.

The book by which Paley holds his own in the world of thought and science is the "Natural Theology," an argument, very largely physiological, that the "design" which manifestly pervades all life is a proof of the existence of an intelligent designer. It is an argument that has to be met, and is not met, by the objectors to it. Indeed, science constantly brings us round again to the signs of an adaptive intelligence incessantly at work in all life. The most surprising fact about this great, simple book, reiterating a single argument through innumerable well-chosen illustrations, is the amount of scientific knowledge that was available considerably more than a hundred years ago, when Paley was building up his book. A good deal of Paley's knowledge was borrowed from Dutch sources, but he arranged his material with great skill; and among all the books which probe the deepest problems of existence there is none that is more readable, as well as more arresting in its contentions, than this. William Paley was not a great man, nor even a great cleric, but he was a consummate arguer; and we can well understand a fact of his college days, mentioned by one of his earliest biographers, "The schools were uniformly crowded when he was expected to dispute."

PHILO

A Philosopher at the Cross-Roads

Philo Judæus, the great Jewish philosopher of Alexandria, who, contemporary with and immediately following Christ, succeeded largely in interpenetrating the speculative philosophy of Greece with the supernatural revelation of the Jews, was born at Alexandria, probably between the years 20 and 10 B.C. His family seems to have been rich and influential, for Josephus mentions that his brother was an important farmer of taxes. Alexandria at that time was a huge, cosmopolitan city, with an enormous population of Jews. It was a very great educational centre, and, in matters of thought, the chief meeting-point of East and West.

Philo seems to have absorbed all the learning of Greece, to have been intimately

acquainted with the works of Plato, and to have regarded the philosophies of the Stoics and Pythagoreans with unbounded respect. The interfusion of his own ideas with those which he had assimilated from the Greek philosophies resulted in an original philosophy in which Greek thought was leavened by Oriental mysticism, and the amalgam had further an important influence on the growth of Christianity.

What personal touch Philo had with Christianity is not clear. It is known that he visited both Rome and Jerusalem. At the age of more than fifty he went to Rome as the spokesman of a Jewish embassy from Alexandria to plead for the revocation of the decree which demanded that every race within the Empire should pay divine honours to the Emperor Caligula. Of course, that was impossible to the Jews. Philo gives a graphic description of his visit in his "De Legatione ad Caium." Eusebius and other Fathers of the Christian Church preserve the tradition that he again went to Rome, and on this second occasion made the acquaintance of the Apostle Peter, but critical opinion receives the statement with doubt. Here the personal story of Philo ceases, but a selection from his works remains, and the influence of his thought is remarkably widespread. Its most familiar form appears in the difference in spirit between the Gospel according to St. John and the other Gospels. Obviously, St. John's Gospel is interpenetrated by the influences of the Alexandrine thought which proceeded from Philo.

Minute examinations of Philo's writings have been made by Schürer, Zeller, and others, so that his system has received the appreciation its importance deserves. The intellectual Jews of Alexandria had long been deeply involved with Greek thought, and had been seeking to find some ground for reconciliation between their conception of the Eternal and the purest Greek ideals. The Pentateuch had been translated into Greek, and a Jewish-Greek literature had sprung up. Indeed, so marked was the Greek influence that many of the Jews had forgotten their own language, and become Hellenistic in speech, nationality, and culture. Thus, while Rome ruled imperially, Greek thought and artistry dominated the world. Even Philo cannot be regarded as a profound Hebrew scholar.

But the Jews, though Hellenised, clung to their religion, and tried to give it a wider influence by grafting it on Greek culture. They were even prepared to tone down or allegorise the literal rendering of their Scriptures if by doing so they could recommend the central features of their creed. Philo felt all these influences, but as regards his faith was conservative. He was Jewish to the core, regarded the Jewish law as a Divine institution, and brought all philosophies to it as a test. The laws of Moses were his final court of appeal, and he held that the best and truest doctrines of the Greek philosophers had long ago been incorporated in the Jewish Books of the Law.

If, as he had learned from the Stoics, human knowledge was delusion, then man must search for Truth in another sphere. If Reason fail, there is still a faculty that can supply man's want, and that is Faith. True science is God's gift, and it springs, he held, from piety. Philo's idea of God was that of a Being indefinable, unimaginable. Finite beings are circumscribed by their attributes. God is without limits; He has no attributes. He is one; simple; everlasting; immutable—better than Platonic Virtue, or Knowledge, or the Beautiful, or the Good. He cannot be otherwise if He exists. But no one can fathom the mystery of His Being—"I am that I am." But, if it is impossible to know God in His essence, there are intermediary Divine forces or ideas that establish an active relation between God and the world. These intermediary entities, says Philo, are identical with the "angels" of the Jews—"a chorus of unembodied souls" occupying the air, messengers of God, through whom He communicates with finite beings.

Philo regarded all these intermediary ideas or forces as comprised in one supreme idea—the Word, or Logos—God's thought, the immanent reason of God. Now, the Greek word Logos means both "Reason" and "Word," so the doctrines of the Logos may be construed in two ways—the one Hellenic and metaphysical, the other Hebrew and theological. And it is also used in the Philoistic Gospel of St. John in a third way, where the Logos, the Word, "the first-born son of God, and mediator between God and man," is made flesh, and "dwelt among men" in the form of Christ. Thus Philo's thought is the gathering-ground where Greek philosophy, Hebrew theism, and systematic theology met. The Alexandrine Jews thought to impregnate and capture Greek thought, but a third competitor dominated the amalgamation; and the elaborate philosophy of the Christian Fathers was built on the interaction of

Greek and Jewish thought around the simple life of Christ and His childlike teaching of a Father in heaven. No man has ever stood more certainly than Philo at the cross-roads of historic thought.

PLATO
The Fountain-Head of All Literatures

Plato, from whom, according to Emerson, come "all things that are still written and debated among men of thought," was born about the year 427 B.C., either at Athens or in the island of Ægina, of an aristocratic family, with Solon as an ancestor on the maternal side. In the fullest possible sense, according to the Greek ideal, he was an educated man, physically and mentally. Quite early he became devoted to philosophy, and at the age of twenty was a disciple of Socrates, whose discussions he attended for eight or ten years. He was present at the trial of Socrates, but not at his death.

Afterwards he travelled extensively, but not as widely as the accretions of tradition would lead us to suppose. He visited various parts of Greece, Egypt, Asia Minor, and Italy, and thrice went for special purposes to Sicily. His object in the first case was to visit the tyrant Dionysius I. of Syracuse, but Dionysius sold him as a slave. He was, however, "bought in" by a friend and redeemed. He went again to try to induce Dionysius II. to establish a Greek colony in Sicily, on a model he would draw up, but he failed. A third visit was to make peace between the tyrant and Dion, who had befriended Plato when he first ventured to Syracuse.

When about forty years of age, Plato settled in Athens, and began to teach in the grove named after Academus, and there remained for about forty years, the leading thinker of the world. He died in his eighty-first year, in 347 B.C., according to some accounts at a wedding feast.

Plato inherited the nucleus of his teaching from his master, Socrates, and particularly his method of discourse; but he broadened his thought constantly during his travels and studies, and so far developed his philosophy that many of his tenets held in later life were inconsistent with his earlier teaching. The discussions carried on by word of mouth in the academy were given a literary form in dialogues, which, in the philosopher's prime, were examples of rare beauty, even when they were most closely reasoned. In later years the style became more severe, with an approach to baldness. Apparently all the writings of Plato have been preserved, but some attributed to him are admittedly spurious. There is no question, however, respecting the authenticity of the most notable of his productions.

Plato did not build up a complete system of philosophy; rather, he established a method of thought with certain fixed leading ideas. Often he discussed subjects—particularly in the earlier part of his life—with a view to the exclusion of error, by Socratic questioning, but did not attempt to sum up the truth as it finally appeared to him. Indeed, singularly little of Plato's writing, apart from certain fixed conceptions which run through all his Dialogues, can be said to embody personal conclusions. Various views are expressed by him as if in controversy, and the main points are allowed to remain open, after unsound opinions have been excluded. In only one Dialogue does Plato himself appear as a talker—in the guise of an Athenian stranger.

To Plato the phenomena of the world which are observed by the senses are only temporary images of real existences which are eternal. To him abstract ideas were the sole realities, and the consideration of them alone constituted philosophy. These abstract ideas, such as goodness, greatness, and beauty, had, in Plato's opinion, a separate existence. They were the substantial forms of which the things men call tangible are only appearances. Aristotle names the one set of appearance *sensible objects*, and the other *intelligible essences*. It is in these intelligible essences that existence is to be found, and they alone are worthy of the contemplation of true philosophers. The things we call real, because they take form in matter, are only blurred copies of the genuine realities which are *ideas* and eternal.

So, too, is the soul immortal. That is why it has glimpses of the eternal realities, the full truth of which can only be seen by the gods; and we secure those glimpses with greater or less clearness in the proportion that we are like the gods. We are born, Plato argued, with recollections of eternal truths that have been known to us in previous existences. God represents the supreme idea of all existence—is the Great Intelligence and the Source of Intelligences. The bond which unites the human and Divine is love—the longing of the soul for Beauty, and Beauty is the most vivid image of Truth.

Is this very ethereal? Well, Plato was a hard reasoner on ethereal things. As George Henry Lewes says in one of the

most elequent passages in his "Biographical History of Philosophy": "He did not look on life or on the world with the temporary interest of a passing inhabitant. He looked on them with an immortal soul longing to be released from its earthly sojourn, and striving to catch by anticipation some faint glimpses of that region of eternal Truth where it would some day rest. The fleeting phenomena of this world he knew were nothing more. But he was too wise to overlook them. Fleeting and imperfect though they were, they were the indications of that eternal Truth for which he longed—footmarks on the perilous journey, and guides unto the goal. Long before him had wise and meditative men perceived that sense-knowledge could only be knowledge of phenomena; that everything men call existence was but a perpetual flux—a something which, always *becoming*, never *was*; that the reports which our senses made of these things partook of the same fleeting and uncertain character. He could not, therefore, put his trust in them; he could not say that Time was anything but a wavering image of eternity. But these transitory phenomena were *images* of true existences. Interrogate them, classify them, discover what qualities they have in common, discover that which is invariable, necessary, amidst all that is variable—discover the One in the Many, and you have penetrated the secret of Existence."

Plato never really came down from this lofty region of philosophical speculation, which to him enshrined a faith. When, as in his "Republic," he attempted to put his thoughts into a practical form, there was a strange unreality in his purely intellectual proposals. We may accept his wisdom, fortitude, temperance, and justice as the supreme human virtues, but what can we think of the mind which formulated these lofty conceptions also suggesting that the rulers of the State should give that State its religion—a proposal which would sanction all persecutions? What can we think of his banishment of poets and musicians from his ideal State? Above all, what can we think of his abolition of all the responsibilities and joys and duties of parenthood and family life—children being unknown to father and mother, and belonging to the State alone? Plato was too transcendental a philosopher to understand human nature, which, after all, more than anything else, makes the world of ideas to move.

His influence in his own day was enormous, and his influence as a connecting link between the thought of the East and the West was greater centuries after his death, and has even had a strongly modifying influence on philosophic Christianity. As Emerson said in the essay already quoted: "Plato's books are the fountain-head of all literatures. He is the mountain from which the drift-boulders of debate have been detached. No wife, no children, had he, but all the civilised nations are his progeny, and tinged with his mind. His writings make it impossible to think on certain levels except through him. He came to join, by contact, the infinity of Asia with the definiteness of Europe. He keeps two vases by his side, one of ether and one of pigment, and he invariably uses both. He paid homage to the illimitable, and added, 'And yet things are knowable.' He saw Nature, he saw Culture, but said, 'There is also the Divine.'"

PYTHAGORAS
The Founder of the Cult of Wisdom

Pythagoras was born near the beginning of the sixth century before Christ, in Samos, and died at a great age, probably about the year 500 B.C. Very little, however, is known of his life, though myths abound. It seems certain, at least, that he visited Egypt, with which Samos was in close intercourse, and learnt something from the priests there. But a man of such magnificent mind needed little help from priesthoods, and we need not question the essential originality of his teachings.

Somewhere about the year 530 B.C., Pythagoras founded a school at Crotona, in Italy, and there he and his disciples practised the moral and religious principles of Pythagoreanism. The heart of this doctrine is expressed in the word "philosopher," a lover of wisdom, which Pythagoras invented in order to describe himself. He preferred not to call himself a "sophos," or wise man, like his contemporaries and predecessors, but a "lover of wisdom." To this high passion Pythagoreanism is devoted. Ordinary worldly pleasures are to be abandoned, and the whole being of the initiate is to be devoted to the rapturous pursuit of true wisdom. Such a doctrine was, of course, opposed to the popular religions of the day, and its followers ultimately had to flee from popular fury.

The novice who sought to enter the society of Pythagoreans was condemned for five years to silence; he had to undergo many humiliations, to test his powers of

self-denial; and, finally, to begin the study of wisdom with mathematics. In this science Pythagoras excelled, and our knowledge of the properties of numbers almost begins with him. Hence we need not be too incredulous if tradition attributes to the Pythagoreans a knowledge of astronomy which was far in advance of their times.

Much of the teaching of Pythagoras was mystical. He taught that the spheres, as they roll, make music, and popular rumour declared that he, the more than earthly philosopher, could actually hear the harmony of the spheres. But he made practical discoveries, too, and is regarded as the founder of the art and science of music. The Greeks used a stretched string, which they called a monochord, and which produced a note when it was plucked. Pythagoras applied his theory of numbers to this monochord, we are told, and discovered how the note is raised an octave if the length of the string be halved; and how, also, if a stop be inserted one-third of the distance along the string, a note and its octave will be produced from the two parts of the monochord thus divided.

PYTHAGORAS

Most celebrated of all is the doctrine of the transmigration of the soul, which was taught by Pythagoras, and which he may possibly have derived from Egypt. A notable reference to this celebrated theory is to be found in "Twelfth Night," in the colloquy between Malvolio and his persecutors. This "opinion of Pythagoras" is held today by a large proportion of mankind.

The Pythagorean society at last became very powerful. The philosopher lectured to women as well as men, his wife herself being a philosopher. The popular voice acclaimed the wisdom of so venerable and unprecedented an order—for a time. His society became a political power, not only in Crotona but in many other cities. Pythagoras chose young aristocrats of both sexes for his disciples, and sought to establish a mighty school of wisdom, where the best of men and women might become better. But of course his followers were unworthy of him. They wanted ordinary secular power, though "his was the ambition, not of a hero, but of a sage." Finally, the people rose, many Pythagoreans perished, and it is doubtful whether his enemies destroyed Pythagoras, or he died, a fugitive, among his disciples. But his name, his life, and his teachings have helped to exalt and ennoble the history and the thought of mankind for nearly two thousand five hundred years.

THOMAS REID

Founder of the Scottish School of Philosophy

Thomas Reid, the founder of the Scottish school of philosophy, was born at Strachan, Kincardineshire, on April 26, 1710, the son of a minister who served the parish for fifty years. His mother belonged to a family of conspicuous ability—the Gregorys. Educated at Aberdeen, he took his degree at the age of sixteen, and was then made college librarian. At the age of twenty-seven he was appointed, by his college, minister of New Machar, against the strong wishes of the parishioners, who, according to tradition, were only restrained from molesting him by a relative who kept the pulpit stairs with a drawn sword while he preached his first sermon. Reid was not an attractive speaker, but his good sense and wise diplomacy soon won his flock over to his side.

On reading Hume's "Treatise of Human Nature," he felt that, if the principles on which Hume based his argument were admitted, his conclusions must be accepted, but he met the case put forward by challenging the principles. His views probably were partly founded on the teachings he had received at the university from Dr. Turnbull. In 1748 Reid published, through the transactions of the Royal Society, an essay on "Quantity," denying that mathematics could be applied to moral questions. Four years later he became professor of philosophy at King's College, Aberdeen, and in 1764 succeeded Adam Smith as professor of moral philosophy at Glasgow, a position which he held for seventeen years. In the year of his removal to Glasgow he published his "Enquiry into the Human Mind on the Principles of Common Sense." His views there expounded were further developed in his "Essay on the Intellectual Powers of Man," published in 1785, and his "Essays on the Active Powers of the Human Mind," which appeared in 1788. The arguments, developed with the aim of delivering philosophy from the scepticism of Hume, were further expanded, with power and eloquence by Dugald Stewart, by Dr. M'Cosh, and by

Sir William Hamilton, who edited Reid's works. The influence of Reid spread primarily through his books, rather than through his activities as a teacher, and the books are for students of philosophy alone. Reid believed that a logical foundation for scepticism was "inlaid," as he said, alike in the works of Descartes, Locke, and Berkeley, and that Hume had brought it to light. Reid's distinction between "sensation" and "perception," and his argument that judgment is the unit of knowledge, are too abtruse to be discussed in a popular form, but they have enough substance to form the nucleus of a national philosophy. He died on October 7, 1796.

ERNEST RENAN
An Emancipator of Religious Thought

Ernest Renan, perhaps the most comprehensive surveyor of all the religious thought that had its origin in the Hebrew race, was born at Tréguier, in Brittany, on February 27, 1823. His father was a Breton, his mother of Gascon descent. Renan père died when his son was five years old, and the boy's upbringing was largely due to his sister Henriette, who was twelve years older than himself. The story of man contains no more beautiful instance of brotherly and sisterly affection and co-operation.

From the first the aim was to prepare the boy for the priesthood, and in this the local Fathers helped to the utmost. They taught him till he carried off all the school prizes, and at the age of fifteen the echoes of his cleverness reached M. Dupanloup, who was training men of influence for the priesthood through the College of St. Nicholas du Chardonnet. There, and at the Seminary of Issy and the College of St. Sulpice, he studied philosophy and philology and Hebrew till he was twenty-two, but by that time he had come to the conclusion that the Church was not for him. It was from his study of the Oriental languages, he declared, that his doubts grew beyond repression; and finally Henriette, who had made great sacrifices to give him a career in the Church, advised him to do what he most strongly felt to be right. So he entered a lay college as a teacher, and at the age of twenty-four made his mark in literature by a "General History of the Semitic Languages."

After some years' service as a teacher, Renan secured a post at the National Library, and began writing for the "Revue des Deux Mondes" and the "Débats" essays which attracted much attention by the charm of their style and their freshness of treatment. Later, these essays were published as "Studies in Religious History" and "Moral and Critical Essays." Studies and translations of the Book of Job, the Song of Songs, and, later, Ecclesiastes followed, and, the Chair of Hebrew falling vacant at the College of France, Renan was admittedly the best suited for its occupancy; but Napoleon, fearing the offence that would be given to the Church by the appointment of one so unorthodox, despatched him on an archæological mission to Phœnicia. There he was accompanied by his sister and wife, for he had married a niece of Ary Scheffer, the painter. His wife returned home, but Henriette stayed with him during his trying Eastern travels, and died in Syria in 1861.

The book he wrote about her, "My Sister Henriette," is one of the most beautiful of all literary family records. On his return to France, broken in health, Renan was appointed to the Chair of Hebrew, but was almost immediately moved out of it for describing Christ as "an incomparable man." He refused the post of sub-librarian of the National Library, and thenceforward lived by his pen alone.

The first of his books after giving up official employment was the "Life of Jesus," of which 60,000 copies were sold in less than five months. Renan now set himself the task of writing the early story of Christianity, and also the history of Israel—the former being brought down in a series of volumes to the time of Marcus Aurelius. He was always busy, too, with miscellaneous writing, and one of the styles he used in dealing with philosophy was a revival of the Greek dialogue.

When he was sixty, Renan published his early biography, looking at the influences that shaped his own life and character much as he would have done had he been summing up a historical personage. He held that the surroundings of his early life in Brittany, where anyone could watch "a fact grow into a faith," specially fitted him to understand the accretions by which religions have been built up.

He passed away on October 12, 1892, declaring that he had done his work, and so died happy. There is no doubt that at the time of his death he was the most widely read serious prose-writer in Europe, but it is very doubtful whether his writing has the qualities that will give it a lasting value. He popularised the study of the language and the early story of the Jewish people, but he did not show in his work as wide and sure a scholarship as has since

been brought to bear on his favourite subjects. His popularity was due in a large degree to a singularly bright style, that invested all he wrote with an almost romantic air, but he often failed in taste, and he had the fatal weakness of raising doubts as to his own sincerity. His opinions on many subjects were constantly in a state of flux, so that no reader could ever be his disciple, however interested he might be in his writings. Sometimes Renan fell into sheer cynicism respecting the inmost intimacies of his own beliefs, as when he said that the most logical attitude towards religion was to behave as if it were true. He brought a picturesque mind to the study of religions in an age of changing methods, and made a bold stand for freedom of thought, so that his writing is built into the story of man's mental emancipation, and will remain interesting, notwithstanding its lack of profundity and of reverence, for he knew no Holy of Holies.

JOHN RUSKIN

The First True "Master of Arts

John Ruskin, one of the greatest personal and intellectual forces in the wonderful era of Victorian thought, was born in London on February 8, 1819, of Scottish parentage. His father and mother were cousins of very mature age. The father was a successful sherry-merchant. The parents made the education of their son the principal feature of their middle age, the mother training him in godliness and the Bible, and the father taking him on his many journeys throughout Great Britain and abroad, and stimulating his love of Nature, art, and literature. Nearly all the main features of Ruskin's later life were the best-developed interests of his boyhood.

He was one of the numerous infant prodigies who have neither died young nor been flashes in the pan. He could not remember learning to read and write. As an infant he wrote poetry. At fourteen he had the passion for the Alps which never left him. At eighteen he had already begun his defence of Turner as a painter. And from the first he was a stylist, his father, while reading to him in early boyhood, calling his attention to the cadences of fine prose.

Ruskin's regular education was desultory in a high degree. He never made exact scholarship an aim, but he went to Christ Church, Oxford, as a gentleman commoner, enjoyed the society, took his degree, and won the Newdigate Prize for English verse. He is one of the great writers who, happily, has told, in his "Præterita," the story of his own youth.

Ruskin's miscellaneous education included a varied training in art. He studied painting with some of the best-known painters of his day, and practised drawing with the greatest assiduity, till he attained a most minute and delicate skill, but he never attempted to compose a picture. Drawing, for him, was an art by which he preserved, exactly, the sight of something he admired. At the age of twenty-four he published the first volume of his "Modern Painters"—a work designed to show their

JOHN RUSKIN
From a photograph by G. P. Abrahams

superiority over the Old Masters. Perhaps it would be better to speak of the volume as the first "draft," for afterwards it was reissued, altered considerably, and this introduces us to one of Ruskin's many peculiarities. He was never satisfied with what he had written, but kept altering it from time to time, sometimes for the worse. The "Modern Painters," though not generally acceptable to the painters of that day, proved conclusively the coming of a great critic and a great master of English. It contained descriptions of objects of natural beauty unequalled. Though Ruskin's writing often grew too elaborate,

and was weakened by a sweetness that seemed deliberately manufactured, at its best it suggested the myriad delicacies of his marvellous appreciation of every form of beauty. To many of the lovely harmonies of Nature that charm beyond speech he could put a speech that was artistry.

From painting he turned to architecture, and at the age of thirty published "The Seven Lamps of Architecture," and, two years later, "The Stones of Venice." His first printed writings had been on the "Poetry of Architecture," in Loudon's "Magazine of Architecture." Ruskin unquestionably modified greatly the modern conception of both painting and architecture, and brought into it a reality as well as beauty that had been missing. He was the first sincere and competent art critic. He united his criticism, too, with extremely useful teaching, as in his "Elements of Drawing," published in 1857, and his "Elements of Perspective," 1859.

But by 1860 he had finished his work in relation to formal art, though he was elected Slade Professor of Art at Oxford in 1869, and held the office ten years. His view of art was inextricably mixed up with morals, religion, industry, political economy, and all else that interests man, and he turned aside to discuss these things, as a lecturer and as a writer, till he lost himself in a whirl of ideas that often had no clear connection with his life's work, except that they always were artistically presented.

As soon as he branched away from his essential work as an art critic, Ruskin adopted, and ever afterwards clung to, the fad of using for his books titles that do not indicate in the slightest degree the contents of the books. "A Note on the Construction of Sheepfolds" was the first venture in this direction, the subject being Christian unity. Who could know that "A Crown of Wild Olive" is a miscellaneous set of lectures, like "Time and Tide"; that "Sesame and Lilies" is a discussion of good literature; that the "Queen of the Air" studies Greek atmospheric myths; that "Ethics of the Dust" deal with crystallisation; "Ariadne Florentina" with wood and metal engraving; "Deucalion" with geology; that "Muneris Pulveris" and "Unto This Last" are statements of the writer's views on political economy and social reconstruction, which were turned out of the "Cornhill" and "Fraser's Magazine" because the readers of those publications could not endure their supposed scientific unorthodoxy; that "Proserpina" is a study of flowers, and that "Fors Clavigera"—a title no one ever really understood—comprised letters to working men on every conceivable subject?

Ruskin's manner of publishing his books was as unusual as his naming of them. He issued them from a workshop privately organised, and he charged prices which he thought represented their intrinsic value. He did not wish anyone to read his books who was not prepared to make some sacrifice to get them. In spite of this rejection of the ordinary methods of business, the works continued to sell, till they brought him a handsome income, which was very convenient, because in later life he had given away nearly the whole of the handsome fortune left him by his father, and he believed in living on capital, ordinary investments being regarded by him as examples of the usury his soul abhorred.

Ruskin, whose mind frequently failed during his later years, lived in great peace, but for recurring mental turmoil, at Brentwood, on Lake Coniston, and there he died on January 20, 1900, having refused all the honours which men of every nation were ready to offer him.

Few great writers have been so fortunate in their biographer. Long before his death, when he was asked for some explanation of one of his works, he referred his correspondent to "a young man at Oxford" who knew far more about his books than he did himself. That young man, now Sir E. T. Cook, has published the final edition of the whole of Ruskin's writings, and has written his Life, with incomparable industry, taste, and ability, so that once and for all this great master is placed in the story of our literature, and in the future no one need mistake either his life or writings.

In his own day Ruskin's life and writings were an incalculable stimulus. They cut right across many accepted ideas, and compelled those who wished to be thought thinkers to think. Though his attempts to organise social and industrial projects failed, and his St. George's Guild died away to a mere name, the only tangible residue of labours in this field being the beautiful little collection of choice objects of art and natural beauty gathered in the Ruskin Museum in Meersbrook Park, Sheffield, Ruskin's ideas are deeply permeating thinking circles. Already they have caused some of the most dearly cherished tenets of the old economists to topple down. His

preaching of a sincere life, satisfied with the great, simple things of Nature, instead of insincere and ostentatious show of things that happen to be a fashion, is bound to come, sooner or later, as a balm to an age satiated with vulgar parade.

In the realm of art he remains the one great writer. He made clear the moral element that is behind all true art, and he brought art right into the consciousness of his own nation, where it had never been before. Art, which meant so much to ancient Greece and mediæval Italy, may never conquer the cold North, but Ruskin unveiled it to all who have eyes to see, and added to it a generous wealth of appreciation of the beauty of the natural world, of earth and air and water, and all their lovely products, stable as in the precious stones, evanescent as in the cloud-drift, with union of use and grace, as in the grass, whose every spike is a sword-blade, and nobility, as in the solemn rest of stupendous mountains. Whether he is more and more appreciated as time runs on depends on whether the vision of the human race contracts or expands. His view of the world should long give delicacy to human culture.

FRIEDRICH WILHELM SCHELLING
A Transcendental Thinker

Friedrich Wilhelm Joseph Schelling was born in Würtemberg on January 27, 1775. He met Hegel at the University of Tübingen, where he studied. Later, he studied medicine at Leipsic, and became the pupil, and in 1798 the successor, of Fichte at Jena. He was afterwards professor at the New University of Würzburg, whence he removed to Munich with a lectureship at Erlanger. Finally, he held the Chair of Philosophy at Berlin from 1841 until his death.

This great thinker belongs to the same school as Hegel and Fichte, and owes much to them. But in his early work the "Philosophy of Nature," published when its author was only twenty-two, and in his "World-Soul," we see him as a great modern pantheist, who sees God in everything. He has often been called the German Plato, but as vast an interval of discovery as of time separates the two thinkers. The thinker whose work forms the true and logical foundation of Schelling's philosophy is Spinoza; and Schelling called Faith in to supplement the more purely intellectual teaching of his pantheistic predecessor.

For Schelling, the whole of Nature is the result, the incarnation, of the realisation of Spirit; so that, in the highest manifestations of Nature, in Man, the World-Soul becomes conscious of itself. "Nature is Spirit visible," he said. "Spirit is invisible Nature." These, and many other sayings of this great thinker, are familiar to English readers, who have met them as the sayings of the poet Coleridge, who was a close and receptive student of the great German.

The "Transcendental Idealism," published in 1800, is Schelling's greatest work, and contains the essence of his philosophy. His "Nature Philosophy" is little more than a curiosity today, for it consists of the kind of explanation of things which will not rely in any degree on observation or experiment, but constructs the world and its workings out of the philosopher's imaginings. It is an example of what Bacon, in his "Novum Organum," taught us to avoid. Much ridicule has been poured upon this "Nature Philosophy," and thence upon Schelling, by experimental students of Nature since his day, but the author was only a boy when it was written, and we should do better to appreciate the later work, in which a noble theory of things was propounded.

Schelling wrote works of less importance in his later years, but his lectures at Berlin had a great influence upon Germany. He died on August 20, 1854.

ARTHUR SCHOPENHAUER
The Philosophy of Will

Arthur Schopenhauer was born at Danzig on February 22, 1788, his father being a banker, and his mother a very copious and clever writer of fiction. Schopenhauer's father was a man of strong and difficult character. There was insanity in the family, and we require to recognise in Schopenhauer himself a very definite and potent mental taint, which affected his life in a large degree, and his thought in some degree. When Schopenhauer was only seventeen his father committed suicide. The widow thereupon went to Weimar, where her son began the study of the classics.

The youth was strange, moody, critical, cynical. He was very unsocial; kept loaded pistols at his bedside, in his groundless fear of attack, and showed, indeed, a very definite combination of the symptons which we call melancholia. In his inheritance, his personal constitution, we find the root of his pessimism, therefore; and we are entitled, as in so many other cases, to look upon part of his philosophy as a morbid product on this account. There are many people with tainted minds, however, and

many cynics and pessimists, but there are few who can think profoundly, and express themselves with force and original eloquence. Of these very few—for the names of the great pessimists may be counted upon the fingers of one hand—Arthur Schopenhauer must be ranked the first.

When he was twenty-five he wrote the treatise for which he was granted his degree at Jena. Already, in this remarkable work, we may see the beginnings of his view that belief and idea spring largely from the *will* of the individual.

In 1819 there appeared the famous treatise on "The World as Will and Idea," which is Schopenhauer's secure title to permanent fame. He learnt, from observation of himself and others, that the will and the emotions of a man largely determine what he shall think and believe. Long before the naïve notion of the materialists, in the latter part of the nineteenth century, that we can discover and believe by the "white light" of pure reason, without prejudice, desire, or passion, Schopenhauer saw and showed that, in fact, our wills determine our ideas and beliefs in all directions, to a surprising extent. The very latest advances in the study of the mind in health and disease, and especially in the study of behaviour, entirely confirm the views of Schopenhauer. Indeed, much of Schopenhauer is implied, and found to work, in those explanations of the delusions and deeds of the insane—and the sane—which Freud, of Vienna, in especial, has given to his contemporaries.

ARTHUR SCHOPENHAUER

The deeper, philosophical aspects of Schopenhauerism are no less significant than some of its practical applications. They appealed greatly to Richard Wagner, whose appreciation must have been valued by the philosopher. For Schopenhauer believed very strongly in himself, and utterly resented the fashion in which he was ignored, while Fichte, Hegel, and Schelling dominated the thinking world in Germany. Wagner, however, greatly admired the theory of music which he had found in Schopenhauer, and was much impressed by the doctrine of the will. In "Parsifal," in "Tristan and Isolde," and notably in the character of Wotan, who embodies the human Will, in the "Ring of the Nibelungs," Wagner has used and illustrated and commented upon the view of Schopenhauer that the will is the real creative agent of living things. Students of the history of thought can also scarcely fail to perceive the relation between Schopenhauer's doctrine of the immanent will as the creator of living forms, and the closely similar and really identical doctrine of Bergson and the "élan vital" which creates and animates the living world.

Schopenhauer wrote nobly and profoundly upon the arts, and the artists of genius, in the third book of his great work. He saw that real tragedy consists in the conflict within the will of the hero, who learns resignation at last through suffering. This was a Greek idea, too. In music, Schopenhauer saw a very profound expression of the human will, and in the laws of music he saw an analogy with the laws of the physical world. No wonder such ideas appealed to Wagner, in whom they were also native. In the great sequence of Wagner's music-dramas, above all in the great trilogy of the "Ring," we find music and poetry blended to express the great and only tragedy of soul-conflict. Wotan, the real hero of the "Ring," is a magnified human being, or demigod, whose troubles come upon him through conflict within his own creative will, which desires low things and high, calls both into being, and then sees the low—the accursed gold of the "ring"—destroy the high, the hero Siegfried, sprung from himself. Anyone may enjoy these works as music, but for their full appreciation we require to realise the profound and everlastingly applicable and pertinent philosophy of man and the world which lies within them, and which their

author owes very largely to Schopenhauer. Yet Wagner always finds hope unextinguished. The "Ring" ends in fire, flood, and the end of the old order, but "the way of the Lord" is made straight thereby, and He is coming. Schopenhauer is one with his artistic interpreter and ally here. We call him a pessimist, as indeed he was, up to a point. That followed, as we have seen, from his personal constitution—even as the principles of his own philosophy. But Schopenhauer is not wholly and ultimately a pessimist; a great gulf is fixed between him and the hopelessness of true pessimism. Our very lives are a product and phenomenon, he declared, of the Will which creates the world; and the end of the phenomenal life of the body does not mean the end of the Will which created it. In Wagner's most human tragedy Tristan and Isolde die, but they die to realise their united wills eternally thereafter. That is not a pessimistic conclusion, but it is consistent with Schopenhauer's teaching.

For this great man, who is indeed no more a pessimist than Buddha, whom he so greatly admired and from whom he learnt so much, taught that the soul can be redeemed from the hampering influence of the body and its other creations, and that, notably by means of Art, and by renunciation of everything that the golden ring symbolises in Wagner's trilogy, a man may purify and exalt his inmost self, the very will of his will, until he passes beyond the visible world, and becomes one with the Godhead. This is the teaching of Buddha, and of Wagner in "Tristan and Isolde," and, above all, in his final work, "Parsifal," where the hero "wins through" to purification, and the realisation of his deepest self, after long temptation and failure.

Hence Schopenhauer stands, when sheer pessimism falls and fails. His great mind rose above the sad limitations which his defects of inheritance and personality involved, and we find the "pessimist," and the critic of "pure reason," becoming a guide to the life of the spirit, and a prophet of great things yet to be.

In later works Schopenhauer showed the splendid eloquence and wisdom which make him one of the great masters of German literature. The debt of the thinking literary and artistic world to him today is enormous, and much underrated by most. In 1831 Schopenhauer went to live in Frankfort, and there he died, on September 21, 1860, after many years of solitary, taciturn. and in some respects pitiable existence

ADAM SMITH

Who Made Political Economy a Science

Adam Smith, whose genius first raised political economy to the dignity of a science, was born at Kirkcaldy, in Fifeshire, on June 5, 1723, not many weeks after his father's death. A delicate, absent-minded boy, with a trick of talking to himself, he attended the grammar school of his native burgh until his fourteenth year. He had a passion for books, an extraordinary memory, and a warmth of disposition that made him popular amongst his schoolfellows. The next three years were passed at the University of Glasgow under such famous professors as Simson, the mathematician, and Hutcheson, the

ADAM SMITH

most eloquent philosopher of his generation. Glasgow was just beginning to help itself to a share of the world's wealth; and the merchandise pouring into its harbours and warehouses from every sea brought lessons that were carefully stored in the lad's mind. He would read a fresh meaning into Hutcheson's favourite formula, "The greatest happiness of the greatest number."

His chief studies were mathematics and natural philosophy. His relatives had mapped out for him a clerical career, and his mother may have dreamed of seeing her son enjoy the emoluments and honours of an Episcopalian bishopric. At seventeen, therefore, after winning a Snell exhibition, he entered Balliol College, Oxford, with a

view of taking Orders in the English Church. He remained there six years, at a time when the reputation of the university was almost at its worst. His college contemporaries were a rowdy and "singularly undistinguished body" of men, but Balliol possessed a fine library; and Smith, lonely and bookish, drank deep from the pure springs of English poetry, and gained that liberal knowledge both of classical and modern literature which was afterwards so serviceable in giving charm to his writings.

In 1746 he took his B.A. degree, and returned to his mother's home at Kirkcaldy. He had relinquished the idea of ecclesiastical preferment, and engaged in further study, "but without any fixed plan for his future life." Two years later the young Oxford graduate obtained an introduction to Lord Kames, and was encouraged by that Scotch lawyer to give a series of what would now be called extension lectures. Edinburgh gave him welcome, and it was there that he started his life-long friendship with David Hume. From the capital he proceeded to Glasgow, where the Senate of the University had appointed him to the Chair of Logic. In 1751 he was transferred to the Chair of Moral Philosophy, a position he held for twelve years, and which he declared yielded him the happiest and most honourable hours of his life.

In the seventh year of his professorship he published "The Theory of Moral Sentiments," a work containing some very ingenious ethical speculations. He argues that moral virtues are the product of sympathy; that we enter into the situations of other men by mentally sharing their passions; and that, by applying to our own actions the same tests of approbation or disapproval to which we subject others, we insensibly develop within us the discriminating force that we call conscience. Edmund Burke warmly praised the book, and said of the diction that "it is rather painting than writing."

In 1764 he resigned his Glasgow professorship, having undertaken to act as travelling tutor to the young Duke of Buccleuch. They were in France for nearly three years, and spent a few weeks at Geneva, where Smith had several conversations with Voltaire in his château at Ferney. He seems to have been greatly bored by his dull stay at Toulouse, for he wrote dolefully to his friend Hume, "I have begun to write a book in order to pass away the time." This book was no other than the "Wealth of Nations." In Paris, Smith and his pupil spent ten months. His "Theory of Moral Sentiments" had heralded his coming. He seems to have been a regular guest in almost all the brilliant salons of the city; and he enjoyed the intercourse of such eminent men as Turgot, Quesnay, and Necker.

On his return to Scotland, Smith went to live with his mother in the old house at Kirkcaldy. A happy and contended bachelor, he spent ten years studying, and composing his "Inquiry into the Nature and Causes of the Wealth of Nations." He had given a course of lectures on justice and police (*i.e.*, policy) as far back as 1762, and this course is practically the draft of his greater work. His manuscript had been destroyed by his own wish, but, curiously enough, a complete manuscript of the lectures, bound in calf and copied neatly from a student's notebook, came accidentally to light in 1876. This fortunate discovery proves beyond cavil that Smith owed little, if anything, to the writings of Quesnay and the French school of economists.

The superlative merit of Adam Smith is that he focussed the best of existing economic thought, and, adding the warm, penetrating glow of his own ideas, illumined the whole region of a hitherto dreary science. His book is not a dryasdust discourse, it is not sprinkled with technicalities, but it is enlivened with odd, out-of-the-way facts and illustrations. It is not merely readable—it is fascinatingly so. His once startling maxims are now simple truisms. "Labour is the real measure of the exchangeable value of all commodities." "It is the maxim of every prudent master of a family never to attempt to make at home what it will cost him more to make than to buy." "The very intention of commerce is to exchange your own commodities for those which you think will be more convenient to you." "In every country it always is, and must be, the interest of the great body of people to buy whatever they want of those who sell the cheapest." "Consumption is the sole end and purpose of all production." And here from Book V., Chapter II., are three of his famous canons of taxation: (1) "The subjects of every State should contribute in proportion to their respective abilities; (2) a tax should be certain and not arbitrary; (3) a tax should be levied at the time and in the way most convenient to the taxpayer."

To understand the revolutionary effect of Smith's teachings on the world's com-

merce, it is essential to recall the cramping restrictions of the old mercantile system which held British shipping in galling bondage for many hundreds of years. It was said by Mackintosh that the "Wealth of Nations" was "perhaps the only book which produced an immediate, general, and irrevocable change in some of the most important parts of the legislation of all civilised States." Pitt mastered its principles when an undergraduate at Cambridge; as a Minister, he adopted them for the groundwork of his policy. Fox eulogised them in the Commons. Cobden and Bright preached them. Peel and Gladstone acted upon them, broke down the barriers of trade, and gave to industry natural free play and opportunity. Germany was speedily converted by them. The world of commerce was liberated from thraldom. It is true that time and the introduction of entirely new conditions of life have rendered much of Adam Smith's doctrine obsolete, but his work has left indelible marks on thought, and the laws of nations.

Smith was made a Commissioner of Customs in 1778. His worthy mother died in her ninetieth year, in 1784. Three years later he was chosen Lord Rector of Glasgow University, and he died on July 17, 1790.

SOCRATES
Truth-Seeker by Inquiry

Socrates, the Athenian philosopher who originated the interrogatory method of argument, was born some time between the years 471 B.C. and 469 B.C. He was the son of Sophroniscus, a sculptor, and Phænarete, a midwife. He received the ordinary education of an Athenian youth, and for a while took up the practice of his father's art. But a wealthy benefactor named Crito was so charmed, it is said, by his manners that he withdrew him from the shop, and gave him opportunities for further study. "When I was young," said Socrates, "I had an astonishing longing for that kind of knowledge called physics." He, however, derived no intellectual satisfaction from physical speculations, and, finding that they led to scepticism, he turned his thoughts to the still deeper task of "knowing himself," and of convicting others of a "false conceit of wisdom."

His career as a teacher did not begin until about middle age. In the meantime he had married Xantippe, whose shrewish temper not only served to perpetuate her memory, but to train her husband in habits of self-control and patient tolerance of opinions contrary to his own. He was certainly cool and unruffled whatever the circumstance. He could cover the retreat of a troop on the field with a courage as undisturbed as when he was shattering the argument of an opponent in the market-place. His soldierly prowess was matched by his unflinching moral courage.

The admirals were improperly sentenced to death for neglecting the sacred duty of burying the dead after the battle of Arginusæ. They fully vindicated their honour, and Socrates, who happened on that day to be the presiding senator, declined to administer injustice, the threats of an infuriated mob leaving him entirely unmoved. That was in 406 B.C. Two years later he refused to obey the malignant order of the Thirty Tyrants when they asked him to assist in the arrest of one of their victims.

But the censor of public wrongs and private folly rarely escapes the penalty that awaits the reformer. And, strange to say, it was the democracy, restored to power, that put Socrates on trial, accused him of impiety and immorality, and condemned him to die. Socrates was a new omen in Greek society culture, and the spirit of philosophical inquiry was opposed to the ancient standard traditions. He had placed himself in conflict with existing prejudices, and therefore, as Heine has profoundly remarked, when "a great soul gives utterance to its thoughts, there also is Golgotha."

The charges brought against him were, firstly, of denying the gods recognised by the State, and introducing new divinities; and secondly, of corrupting the young. The defence did not mollify the jury: if he had disparaged State institutions, he was prepared, without hesitation, to obey the laws; if he rejected mythological interpretations, he had accepted the established faith and diligently performed the ritual sacrifices; and surely it was not a fault so to teach the sons as to make them wiser than their fathers. His heterodoxy, and the popular distrust of intellectual innovation, were his undoing. His demeanour during the trial, grave and placid, with the natural dignity that comes from innocence, increased the anger of his adversaries, and the verdict went against him. He might have escaped from prison, but his reverence for the laws of his country overcame every other sentiment. He drank the hemlock "with exceeding facility and alacrity," says Plato; and his faithful and affectionate biographer, Xenophon, wrote a beautiful panegyric of him in the "Memorabilia."

Once seen, Socrates was not likely to be forgotten. His grotesquely odd face and figure were caricatured by actors on the stage, and his features wrought by potters into their jugs of earthenware. "His powers of endurance were unfailing; he had so schooled himself to moderation that his scanty means satisfied all his wants." Shoeless and shirtless, he was, notwithstanding, the hardiest patriot in Athens. He was a mellow humourist, and a welcome guest at the feasts of young men who delighted in his conversation. His vocation was talking, and when he talked nobody thought of his ugliness. He invented the art of cross-examination, and in this twentieth century would probably have been the acknowledged leader of the Hellenic Bar. The underlying purpose of his talk was the exposure of ignorance and the discovery of truth; and fortunate was the sceptic who could disentangle himself from the meshes of the web that Socrates wove round him.

Emerson truly says of him: "A pitiless disputant who knows nothing, but the bounds of whose conquering intelligence no man had ever reached; whose temper was imperturbable; whose dreadful logic was always leisurely and sportive; so careless and ignorant as to disarm the wariest and draw them in the pleasantest manner into horrible doubts and confusion. But he always knew the way out; knew it, yet would not tell it."

From Aristotle it may be gathered that "there are two things of which Socrates may be justly regarded as the author, the Inductive Reasoning and Abstract Definitions." Socrates has sometimes been compared with Bacon; but while the latter searched for truth through the interrogation of natural phenomena, the former attempted to discover it through the operations of the mind. Socrates was indeed a psychologist. In another passage Aristotle says: "Socrates concerned himself with ethical virtues, and he first sought the abstract definition of them." He believed that every man must discover truth by the intellectual wrestlings of his own mind; that the mind must be stirred and awakened; that knowledge could not be crammed—it must be elicited. But he was an educator. As his mother's skill was helpful in bringing children to birth, so he might help others in giving birth to an idea. Hence he hit upon the "question and answer" method of education. In moral science his two fundamental principles were that Virtue is Knowledge and Vice is Ignorance; that, therefore, if man has gained practical wisdom, right action will necessarily ensue; and, where a man is ignorant, evil action will, involuntarily, be the consequence. This doctrine is, of course, untenable, leaving out of account the influence of human passions and basing conduct on knowledge alone. Socrates left no writings, and almost all that is known of him is due to the works of his disciples, Plato and Xenophon. A martyr to philosophy, this "most virtuous and happiest of mankind" died in 399 B.C.

HERBERT SPENCER
Philosopher of Universal Evolution

Herbert Spencer was born at Derby on April 27, 1820. In the copious and valuable autobiography, posthumously published, we find a very long and detailed account of his relatives and ancestors; and perhaps the feature of the stock which is most conspicuous upon such inquiry is its nonconformity. The members of this family persistently thought for themselves, and acted as they believed, without reference to tradition, custom, or consequence. From first to last, throughout his long and sternly conceived life, Herbert Spencer was true, in thought and deed, to this principle.

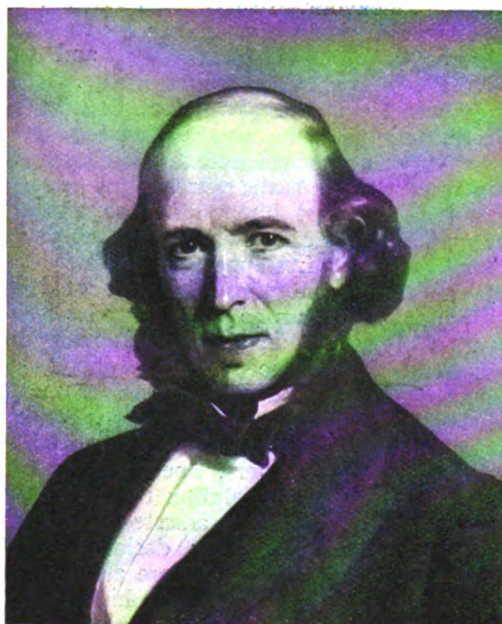
Spencer owed much to his father (a schoolmaster of no ordinary kind), to a paternal uncle, and to his mother. The autobiographical passage upon his lack of adequate appreciation of her is touching and memorable, not least because it reveals the extraordinary depth of emotion and passion which ever existed under the controlled and apparently bloodless exterior of this man's mind. But, indeed, there are many other such passages in the autobiography, notably the reflection upon the Pyramids, the observations upon his love of children, and the last pages, in which the destiny of man the individual and Man the Race is discussed. Many who knew Spencer personally have regretted the extent to which the human and lovable side of him has been suppressed in his account of his own life. This autobiography, published in two large volumes in 1904, is now to be obtained in cheaper form; and while much of the nineteenth century seems to have shrunk strangely at this little distance, such a piece of self-revelation, and of profound reflection upon the problems of philosophy and science, increases in value as the years proceed.

Spencer was not very happy in his school-days, but there he began those observations and thoughts which later showed them-

selves in his little book on Education, published in 1861. This is the volume with which the student of Spencer should begin. It entitles him to his acknowledged and often attested place as the greatest educational reformer of the nineteenth century. The essence of his teaching in this book, which is now read by students and teachers in every civilised language, is that education must deal with the *whole* nature of the child—"to prepare us for complete living is the function which education has to discharge"—and that, therefore, it must begin with an understanding of the nature of the child. Here, of course, is implied that respect for childhood which helped the author to write a "Principles of Psychology" that made a new epoch in that subject, and which we see illustrated in his autobiographical remarks upon the behaviour of adults in the presence of children, and the insolence and folly of forcing oneself upon them against their will, as if they were not persons as much as we. It is, above all, this discovery of the sacred personality of the child that makes Spencer's "Education" an immortal masterpiece.

After several years of railway engineering, Spencer began to write extensively—in his early and middle twenties. The "Proper Sphere of Government," to quote the title of his early letters to the "Nonconformist," was a subject that always interested him, and from the first to the last we find him an Individualist, looking jealously upon almost every activity of the State, and admitting exceptions to his principle only in the case of needy childhood.

Then, after many years, Spencer had occasion to review and revise all his existing and scattered essays. Therein he found a principle; and the rest of his life was devoted to its exposition. All else was sacrificed; he spent all his little patrimony upon the expenses of publication. He remained a bachelor, destroyed his health, lived laborious days and sleepless nights; but thirty-six years saw the completion of the "System of Synthetic Philosophy," in which the principle which he taught us to call "Evolution" was applied to all things.

Spencer had met George Eliot and G. H. Lewes. Her he admired immensely, and he it was who advised her to try the writing of novels. The influence of his thought (to those few acquainted at first-hand with a thinker whose thought is now part of daily currency) is to be found throughout her writings. Lewes interested him in psychology and the history of philosophy. In 1857, the year of Comte's death, he introduced the word "evolution" in its modern meaning, and sketched out a scheme of its application to all the sciences. Two years later came the "Origin of Species," applying the idea of evolution to living things, and offering the theory of "natural selection" to account for it. Spencer read this work with delight, recognised the unsuitableness of the phrase "natural selection," and suggested the "survival of the fittest." Darwin gladly accepted, and thereafter used, the more accurate and less question-begging term, which is, together with "evolution," the most famous and familiar of Spencer's many intellectual coinages, though "the social organism" is scarcely less so.

HERBERT SPENCER

As early as 1852, Spencer had accepted what we now call, thanks to him, organic evolution, and what he then called the "Development Hypothesis." In 1855 he published his first volume on Psychology, in which the minds of children, savages, and animals were, for the first time, properly appraised for philosophy, which had hitherto never condescended to look at anything less than the mind of the philosopher himself. The years 1860–96 yielded the volumes of the "Synthetic Philosophy," from "First Principles," through "Principles of Biology," "Principles of Psychology," and "Principles of Sociology," to "Principles of Ethics," for the sake of which the whole was undertaken. The Sociology was, in fact,

published last, for the author hastened with the Ethics, fearful lest he should die before writing that for which he had long laboured.

The works of Spencer are now being republished in cheap editions, and the "Descriptive Sociology," a great chart, as it were, of the social life of mankind, is being completed by the aid of the money he left. It had to be discontinued during his lifetime, after he had "lost" upon it many thousands of hard-earned pounds. "First Principles" and the "Data of Ethics" are already published in the cheap edition; and they furnish the foundations and the culmination of the great edifice, which is surely the most magnificent and complete intellectual achievement and creation in the history of human endeavour. In its earlier years this work owed much financial help to the generosity of John Stuart Mill, and to several admirers in the United States.

It is the very general opinion of students of Spencer that the weakest part of his teaching, and that which least depends upon his own principle, is the extreme individualism which caused him to oppose almost every socio-political development. Yet we may live to see a fresh need for the assertion of the truth that the behaviour of the individual continues to matter, under any system of laws. For the rest, it may be asserted that time steadily increases Spencer's fame. When all the astronomers had rejected Laplace, and thought all nebulæ would be resolved by bigger telescopes into star-clusters, Spencer opposed them, and asserted evolution in the skies. When nearly all chemists asserted atoms to be unchangeable, Spencer declared that evolution would be found there also. The twentieth century has proved him to be right. Today we "think in evolution," and none use Spencer's ideas more constantly than those who have not the faintest idea of their source.

Herbert Spencer died, after many years of invalidism and weariness of life, on December 8, 1903. Many books have been published dealing with his system and himself. The most recent of these, called "Evolution the Master-Key," by Dr. C. W. Saleeby, is an attempt to show how the Spencerian philosophy applied to and is confirmed by the new discoveries made since its author's death. The "Life and Letters," by Dr. Duncan, was published in 1908, and is a fine and just memorial to one of the most independent, honest, devoted, profound, and fertile minds in the history of human thought.

BENEDICT SPINOZA
Who Saw All Things as the Vesture of God

Baruch, or Benedict, Spinoza was born at Amsterdam on November 24, 1632, of Jewish parents from Portugal. He was a delicate child, doubtless already tuberculous, and was allowed by his father to receive a rabbinical instead of a commercial education. Much was hoped from him by his delighted teachers; they did not know how much this boy of fourteen was going to learn. With excommunication about to be pronounced, he withdrew from the synagogue. He changed his name of Baruch to Benedict, and renounced dogmatic and traditional Judaism, with its limited conception of Deity as a tribal God, the peculiar possession of a "chosen people." The excommunication was actually pronounced when Spinoza was twenty-two.

The brave youth set to work to master Latin while he made a pittance by the polishing of lenses for optical instruments. As he polished, his spiritual eyes saw more than ever lenses of glass could reveal. He was introduced to the Latin writings of Descartes, in which he found a new world revealed. He left Amsterdam for a small village near Leyden, and there he polished lenses and wrote a masterly abridgement of Descartes' "Meditations." Some fame came to him, and a Royal patron offered him the Chair of Philosophy at Heidelberg. But his acceptance of it would have required him to conceal that part of his beliefs which ran counter to the limitations placed upon Deity by theologians, and he refused the Chair, for his "public duties would interfere with his private meditations." He preferred to polish lenses, and be free to think. He declined money and legacies from his friends, refused a pension conditional upon his dedicating a book to Louis XIV., "having no intention of dedicating anything to that monarch," and lived at home on a diet which cost him about twopence-halfpenny a day.

The "God-intoxicated Spinoza," Novalis called him. But his enemies thought otherwise. He founded what we now call the "higher criticism" of the Bible, and attacked the institution of priesthood. They said he was an atheist, because they could not see his God. Yet he sought to proselytise none. He encouraged children to be regular in attending church; he assured his landlady that her religion was a good one, and would save her if she lived a kind and upright life, besides going to church. And from his tiny earnings, and his meals of

gruel and raisins—for he would not go out to dinner, though often asked—he found somewhat to spare for the wretched; and all the time he was dying of consumption.

Among Spinoza's various works, two stand out; first, the "Theologico-Political Tract," with its discussion of the meaning of revelation, and its criticism of the dogma which denies man's right to think; and second, the "Ethics," which is not merely a treatise on morals, but is the most exalted system of pantheistic philosophy ever given to the world, and has profoundly influenced the great minds of every generation since Spinoza's death. In his own day it won for him the name of atheist, though, indeed, what his critics called atheism was really *acosmism*—a denial that the cosmos is anything but the living garment of God. That phrase is Goethe's; and the supreme poet of Germany was indeed a humble pupil of Spinoza. So were Novalis and Lessing and Herder, and Coleridge and Wordsworth, each in his own way and measure seeing and teaching what true thinkers have always finally come to see—that in God we live and move and have our being.

Early in his twenties Spinoza was already threatened with death from consumption. As so often, the disease ran a protracted course. It left him time to do the essential part of his work in the world. For six years he had lived at the Hague, when, in 1677, his symptoms became much worse, and on Sunday, February 22, he died suddenly in the presence of his doctor, his friends having gone, at his earnest request, to worship the little God in Whom they believed, and who, he was teaching mankind, infinitely transcends thought. On their return they found him dead, his doctor having departed, taking with him Spinoza's watch and money.

Such was the earthly end of this sublime thinker, who taught that the visible world is the outward and visible sign of the ever-creative and definite Being, the Substance from Whom all things visible and invisible proceed. "Offer up with me," says Schleiermacher, "a lock of hair to the *manes* of the holy but repudiated Spinoza. The great Spirit of the Universe penetrated him; the Infinite was his beginning and his end. He was filled with religion, and therefore he stands alone, unapproachable —elevated above the profane world, without adherents and without even citizenship." Citizenship, indeed! No "common follower of the world" was he, but the "clearer presence of God Most High in a man."

THALES
The "Father of Philosophy"

Thales was born at Miletus, a Greek colony in Asia Minor, in the seventh century before Christ, the exact date being unknown. He belonged to a distinguished family, and is said to have taken a part in political practice as well as in philosophy. He was one of the "Seven Sages" of the ancient world, and is perhaps famous, above all, for his profound motto, "Know thyself."

As a student of the external world he founded philosophy and science, in so far as these have a historical record at all. He saw that things change, and sought for a principle or beginning of change. He thought he had found it in water, and so he came to teach that from water all things have evolved, and to water they will all return. Even in earth, in germinating seeds, in his own body, he found water; without it, nothing could happen, and it must therefore be looked upon as the beginning of things. The modern student of the chemistry of living beings goes far to confirm this principle of Thales, in a limited but notable sense. But of course Thales had not hold of the whole truth; and his successors had to make other suggestions, as that everything began with fire.

Apart from the maxim "Know thyself," Thales is most to be honoured, however, for his assertion of the great principle now called the "conservation of energy," which plays such a part at the very foundation of physical science today. "From nothing, nothing is made," he taught; in Latin form, "Ex nihil, nihil fit." Things are neither created nor destroyed; they change.

Little more is known of the teachings, and no more of the life, of this remote thinker, but on the historical record his name stands illustrious and first.

TOLSTOY
Reintroducer of the Christianity of Christ

Count Leo Tolstoy, the greatest personality of the Russian race, was born at Yasnaya Poliana, Tula, Russia, on September 9 (new style), 1828, of an aristocratic family notable in Russian history. His mother was a princess. Both she and his father died when he was quite young. He was a thoughtful boy, but no determining influence gave him a lead, and he had to make his own way to a theory and practice of life. Sent to the University of Kasan, he saw little to respect in the education offered. His studies were of a very desultory character, and he left in disgust.

He included Rousseau in his reading, however, with permanent effects on his thoughts and character, and from quite early years he had in consequence recurrent hankerings after "the simple life."

He came under discipline by joining the army and seeing service, first in the Caucasus, and then in Bulgaria and the Crimea. During this soldiering period he began to write, and at once arrested attention as one bound for distinction. Indeed, during the Siege of Sebastopol—respecting which some of his most vivid stories were written—the Tsar Nicholas gave orders to the superior officers that Tolstoy should be kept out of any unnecessary dangers which he might seek, as his life was evidently destined to be useful to his country.

In writing of Tolstoy it is necessary to be clear which Tolstoy is meant, for no man ever changed more in the course of a lifetime, through growth and conversion. When ranging a library containing all his works it is possible to meet at least three different Tolstoys; and it must never be forgotten that, as his views of life developed, he denounced himself as a novelist as vigorously as he denounced nearly all other writers of fiction. It was not that Tolstoy's works were ever deleterious, as fiction goes from the point of view of the average cosmopolitan reader, but he entirely changed his conception of what human qualities constitute the real values of life. In this brief notice of him it is Tolstoy the philosopher, the real, ultimate man, that we have to deal with, and his earlier works only call for the merest mention.

His first period as a writer was almost co-terminous with his life in the army. Then he wrote a semi-autobiographical account of his youth, war-sketches, and stories which showed markedly the influence of Rousseau. Afterwards he travelled, with the fame of his early writings gaining him friends, particularly in literary circles; married happily, had a large family, and devoted himself to them and the management of his estate. Next followed, to the age of fifty, a period when his greatest novels were written—the magnificently panoramic "War and Peace," and "Anna Karenina." But, as time went on, Tolstoy was more and more restless, because he had no settled philosophy or practice of living which satisfied his aspirations, and especially put him in a right relation toward the mass of his fellow-men, the peasants, in whom he had seen, as common soldiers, manly virtues which he found far less developed, or more overlaid, in men of his own circles. In 1867, when he came back from his travels, he had given all his own serfs their freedom; and now, as his spirit was maturing, he determined to live a life of peasant simplicity himself, to make his whole life a religion, and to give himself up to teaching that religion. What he wrote and did during the last thirty years of his life—whether as argument, appeal, or story—had that aim; and in that faith he died on November 20, 1910. His object, in a word, was to bring back Christianity to the practice of Christ. It need hardly be said that in pursuing this object he was excommunicated by his own branch of the Christian Church—such men always have been, and apparently always will be, stoned by the guardians of formally organised religions, who cannot tolerate those who are too religious. What is the philosophy, then, which Tolstoy expounded, though it involved the renunciation of much that he had done and written in the earlier part of his life?

He held that the secret of a perfect life is to be found in Christ's actions and teachings; and they are summarised in love for all mankind, which leads to human helpfulness, and to abstention from everything that would harm others. This, he held, was the essence of every form of religion that has been sincerely evolved by men. On this basis we arrive at once at human brotherhood, irrespective of caste or race, social or blood distinctions. Out of this feeling of brotherhood, and one of the great tests of it, sprang his theory of non-resistance, adopted from Christ. The theory carried him far beyond such decisions as refusing to be a soldier, or refusing to resent any wrong or resist any violence. It led him to reject the participation in, or acceptance of protection from, any form of government, because Governments are based on the use of force when it appears necessary. He regarded all the actions of the State as contrary to true Christian teaching, as, for example, the enforcement of the law, which does not forgive men, or return good for evil. Indeed, he thought of the State as an organisation for enslaving the people to anti-Christian practices. For the same reason he opposed State Socialism, and advocated communal control of land through Henry George's Single Tax for absorbing the whole of the "economic rent." He would destroy landlordism by passive resistance on the part of the workers. The aim of every human

being should be to sink his own personal interests for the good of mankind generally —only thus can true satisfaction for a life of genuine worth be reached. Science, religion, art, politics, are all judged by him in their relation to this great aim, which was the supreme aim of the life of Christ. Through many books and pamphlets Tolstoy preached his gospel of ideal perfection, and in simplicity and sincerity strove to carry it out in his own life.

VOLTAIRE

The Man who Freed the Mind of France

THE name of Voltaire was François Marie Arouet until he was thrown into the Bastille, whence he emerged as Voltaire. His father was Arouet, the notary, a very well known business lawyer.

Born on November 24, 1694, in Paris, Voltaire was a weakly child, whom his parents scarcely hoped to rear. His mother died when he was seven, and the lad grew into a dissolute but clever young man, whose tongue and pen were to be feared by friend and foe, much to the distress of his father, who hoped to see him a great advocate instead of a prickly society wit. He had been educated from the age of ten at the Collège Louis le Grand by the Jesuits, but he declared afterwards that they taught him nothing. On leaving the college he would not look at the law, and his friends were all badly chosen. A friend of his mother, who saw the possibilities in him, and gave him two thousand francs to buy books, was, according to Morley, "the one honest soul with whom he had to do." To separate him from undesirable associates, his father secured his attachment to an embassy to Holland, but he was sent back home in consequence of an intrigue with a lady about the Court. Returning to Paris, he brought matters to a head by lampooning the Regent, and for this, in 1717, he was sent to the Bastille, where he remained out of harm's way for nearly a year. He now wrote his tragedy "Œdipe," which was performed with immense success, and an epic poem with Henry IV. of France as its hero, for which sanction was refused by the authorities. The poem, however, was printed, smuggled into Paris, and widely read. Voltaire continued writing for the stage, and was regarded as the most brilliant man about town, when an event occurred that made a man of him indeed. Having lampooned a sprig of nobility, his young mightiness set his lackeys to thrash the impudent scribbler. Voltaire replied with a challenge to fight, and was promptly clapped in the Bastille, from which he was only released on the condition that he would go away to England and stay there. He was in his thirty-third year when this occurred, and he stayed in England three years. Voltaire's later influence on the world depended wholly on those three years. Till then he had been a trifler. He now became an earnest man, even something of a philosopher, with a deepened knowledge and an aim in life as regards his own country.

Looking back on the England of George II., we may not see at once that it was the land of freedom, but to Voltaire, fresh from a land where all freedom of thought was fettered, and civilisation itself

VOLTAIRE

was being slowly strangled by the Church and aristocracy, the sense of expansion and power was exhilarating in the highest degree. He at once became the friend of the men of most vigorous mind. He learned English, read Locke, mastered Newton, knew Pope, Young, Thomson, and Gray, and absorbed Deism from Bolingbroke. Of Locke he said, in a sentence that is a fine example of his caustic delineation: "Like a prodigal returning to his father, I threw myself into the arms of that modest man, who never pretends to know what he does not know, and, in truth, has no enormous possessions, but whose substance is well assured." In 1729 Voltaire went back to France, a

made man. He had now published his "Henriade," dedicated to the English Queen; had collected the materials for his shrewd but curiously patchy "Letters on the English," and was prepared to introduce Newton's philosophy to his own countrymen, to write on metaphysics, and to dabble in an amateur way in experiments in physics and chemistry. Above all, he felt keenly what the freedom was which England had and France had not, and was prepared in every way to fight for free play for human reason, whoever might try to stifle it.

As Morley says, with fine, picturesque truth: "He made it a perpetual war-cry, and emblazoned it on a banner that was many times rent, but never out of the field." During the next twenty years, while he was fighting the battle of mental freedom, and, as has been said, "purging and exalting belief by disbelief," he had to change from residence to residence and in and out of the country to evade what he called "the enemies of man," and particularly the Church he delighted to name "L'Infame." "He hated tyranny, and refused to lay up his hatred privily in his heart." The resistance to the principles of despotism, which had been made successfully in England in the seventeenth century by "a band of homely squires" like Cromwell and Hampden, was first made in France, more than a century later, by Voltaire.

He stood for the rational man, and he forced his enemies to become rational in trying to defend themselves. Still, by 1750, he found it advisable to leave France, and accept the long-given invitation to visit his friend Frederick the Great. In Berlin he was installed "with sumptuous honour," in fine apartments, and was given a handsome pension. But the visit was a mistake; and Voltaire, who, as a side-show of his character was a cunning business man, and always piling up a big fortune, engaged in transactions which Frederick could not countenance in a protégé, however eminent. So the friends parted, not without bitterness, though the friendship was nominally sustained, and the writings in which Voltaire scalped the King were kept *perdu* in his desk, to be found when he was dead.

Voltaire now settled for the last twenty-three years of his life on Lake Geneva—wealthy, infinitely busy, and one of the admittedly supreme personages of Europe. Here he wrote some of his greatest books; from here he fought some of his stoutest battles against oppression and the insolence of proud and stupid authority. His death was strangely caused. He had been absent from Paris for thirty-four years, and was now in his eighty-fourth year, when he was invited to Paris to the production of his play "Irêne." Its success was immense, and the reception of Voltaire by the populace one of unbounded enthusiasm. The excitement of finding himself the darling of his countrymen was too much for the cynical old man, who so long had hidden his heart; and in the midst of a blaze of popular glory he died, at the height of his fame, on May 30, 1778.

To many English people Voltaire remains the typical infidel—which shows how successful his enemies were in throwing dust into the eyes of many good people in defence of indefensible pretensions. It is quite true that Voltaire had no sense of reverence, but the things he fought were not reverend. As Morley says in his superb sketch: "The Christianity he assailed was as little touched as Voltairism itself with that spirit of holiness which poured itself round the lives and words of the two great founders, the great Master and the great Apostle." Voltaire never was an atheist.

Indeed, a time came when the more advanced of his countrymen looked upon him as a conservative in religion. "He is a bigot—he is a theist," was the cry. It is true that his methods of controversy were recklessly "keen," and he constantly failed in taste; it is true that his influence was destructive—he attempted no constructive legislation. He can be criticised at a hundred points, and then the main fact of his life will stand that he awoke his country to a consciousness that human intelligence has the right to free play. As Morley says, in a piece of daring imagery: "The rays of Voltaire's burning and far-seeing spirit no sooner struck upon the genius of the time, seated dark and dead like the black stone of Memnon's statue, than the clang of the breaking chord was heard through Europe, and men awoke in a new day and more spacious air."

XENOPHON
The Founder of the Literary Essay

Xenophon, Greek historian, military commander, and founder of the literary essay, was born at Athens about 430 B.C. He was the son of an Athenian knight, and came under the influence of Socrates at an early period of his life. In 401 B.C. he accepted the invitation of an old friend to join the Hellenic mercenary troops in an expedition which Cyrus the Younger was leading

against his brother, Artaxerxes II., king of Persia. Xenophon's motive was not the love of fighting, but a keen desire to see strange lands and to witness thrilling adventures. He would have made an excellent war correspondent. But after the battle of Cunaxa, in which Cyrus was slain, Xenophon was elected an officer, and finally placed in command of the Greek force.

Though continually harassed by savage foes, he succeeded, by means of strategic skill, genial tact, and steady resolution, in leading his men through the bleak highland tracts of Armenia and Georgia; and after five months of severe privations they reached Trebizond, on the Black Sea, and eventually Chrysopolis (Scutari). The "Retreat of the Ten Thousand," inseparably associated with the name of Xenophon, is one of the great military achievements of all time. In his "Anabasis," he tells the story of the march with much vivacity and picturesque detail.

After some service under a Thracian chief, the well-seasoned little army crossed over to Asia again, and assisted a larger Lacedæmonian force to wage war against their old enemies the Persians. Xenophon luckily captured a rich noble and his family, the ransom paid for their release being sufficient to endow him with a small fortune. Upon his return to Greece, he fought at the battle of Coronea (394 B.C.), siding with the Spartans against Athens and Thebes. The explanation of this seemingly unpatriotic conduct lies in his belief that the union of Athens and Sparta would enable Greece to dominate the world. His native Athens would not adopt this policy, and decreed his banishment. Sparta recognised his services by the grant of an estate; and on this he lived with his wife and two sons for the next twenty years. He played the part of a country gentleman, writing most of his important works, and hunting with the zest of an ardent sportsman.

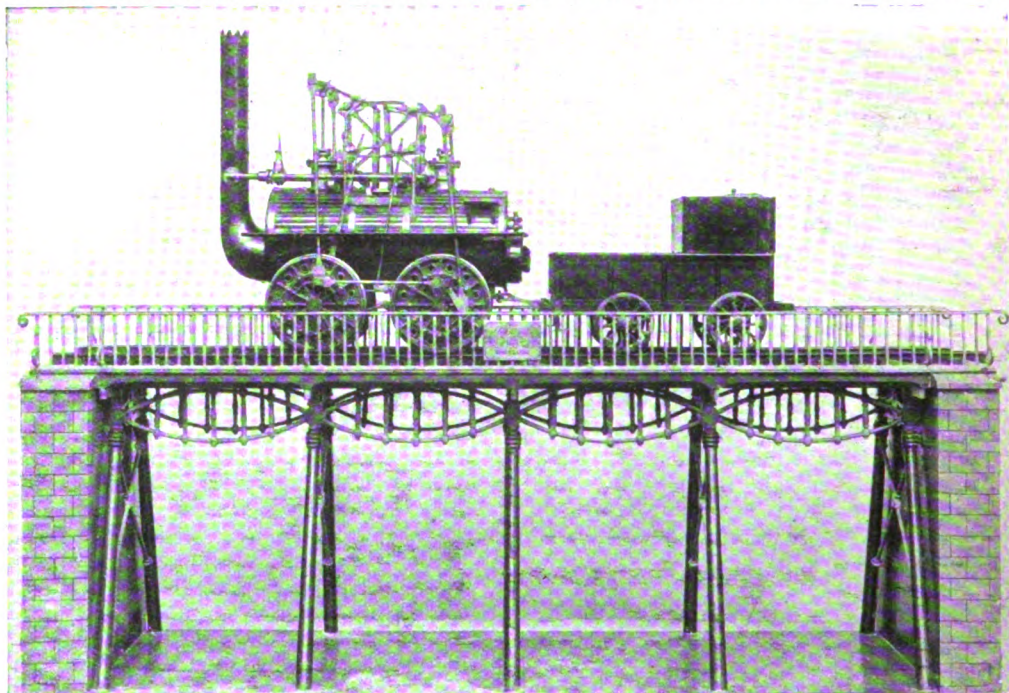
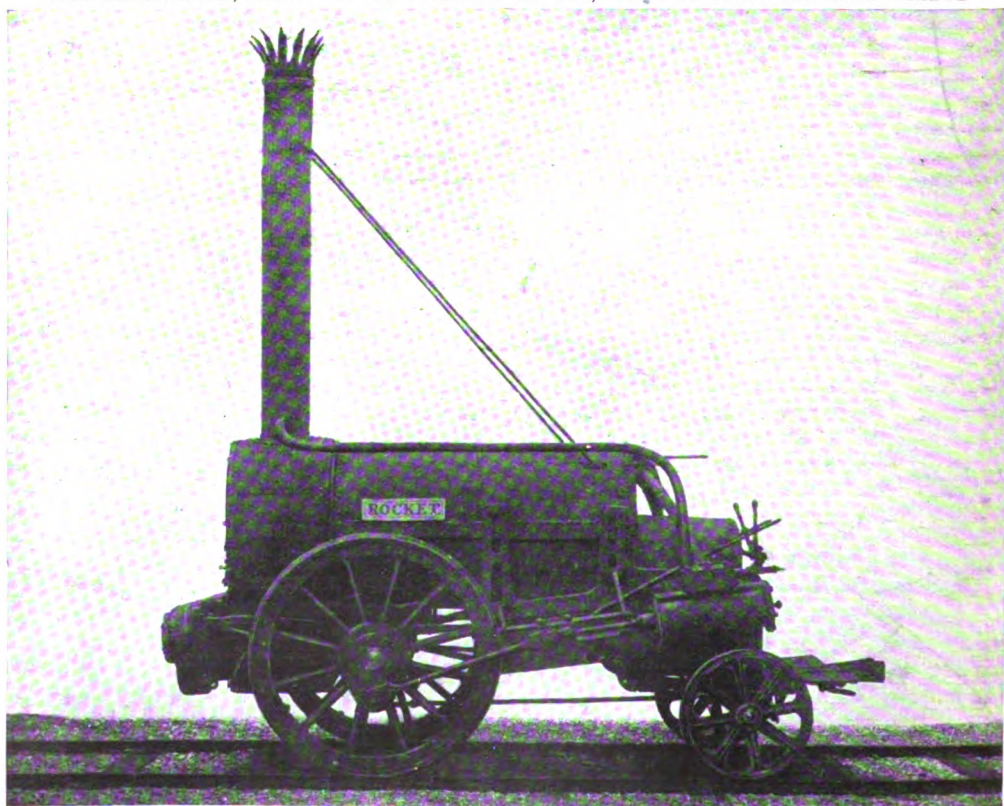
The philosophy of Xenophon was adapted to the needs of his times. He was not an idealist, and his genius was not given to utopian speculations. It was the moral and practical aspect of his master's teaching that had impressed him most; and his own writings are utilitarian in purpose, his thoughts being largely suggested by social and national environment. So that he aims at creating capable soldiers and good citizens, forming thrifty housekeepers, and inculcating such principles as would vitalise commerce and govern useful legislation. In his "Œconomicus" he presents a lively and entertaining picture of a Greek wife. She would be devoted to home duties, and strive to preserve her personal attractions by healthful exercises; not by painting her complexion. He assumes that difference of sex implies difference of aptitudes, and considers intelligent co-operation is the true secret of domestic happiness. He eulogises agriculture as a calling which fosters a love of country and respect for property, which hardens men for military campaigning, and which allows sufficient leisure for intellectual pursuits and political activities. He recommends kindly treatment of labourers, but lays emphasis on the value of efficient personal superintendence.

His essay on the "Revenues of Athens" is a very practical treatise, in which he makes various suggestions for raising home revenues. One of these was to lease public lands for mining enterprises, and the hiring out to capitalists of slaves purchased by the State. His remarks on finance are interesting, if not always clear and accurate. He had, however, grasped the principle that the export of money in exchange for goods involved no loss to the community. He was a precursor of Cobden in his advocacy of international amity, and of diplomacy in the settlement of foreign disputes. Today he would be called a pacificist and Free Trader.

His essay on "Horsemanship," on "Cavalry," and "The Chase" are scientific treatises on subjects upon which he was an expert authority.

The "Memorabilia" embody Xexophon's remininiscences of those famous Socratic conversations by which the great philosopher educated his disciples. Socrates never wrote a book. His biographers were Plato and Xenophon. But while the former often cast the glamour of his own imagination over his master's portrait, Xenophon gathered up such moral and matter-of-fact principles as would appeal to a pious and straightforward soldier, and with these drew a simple, honest, but imperfect sketch; so that it has been said that he gave "considerably less than the real Socrates, while Plato gives us something more." Xenophon was, in truth, the Boswell of Socrates. His great historical work, besides the popular "Anabasis," is the "Hellenica," a continuation of the history written by Thucydides.

After Sparta's memorable defeat at Leuctra, 371 B.C., Xenophon made his home in Corinth. He was still alive in 357 B.C., but how long he survived after that date is unknown.

EARLIEST TYPES OF RAILWAY ENGINES

THE LOCOMOTION, BUILT BY STEPHENSON IN 1825, ON THE FIRST RAILWAY BRIDGE

THE PRIZE ENGINE ROCKET, BUILT BY STEPHENSON IN 1829

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INVENTORS

DENIS PAPIN

Who Made the Steam-Engine Possible

DENIS PAPIN was born at Blois, France, on August 22, 1647, the son of a physician, and was himself brought up to the medical calling. After taking his degree, he devoted himself to the study of physics, and, joining Huygens in Paris, helped him in his experiments with the air-pump.

Persecuted with great bitterness as a Protestant, Papin fled to England, where his experiments had already made him known. He was warmly received by Robert Boyle, whom he assisted in his laboratory, and under whose auspices he was introduced to the Royal Society. It was to this body that Papin first exhibited his famous "digestor," an appliance for cooking by means of superheated steam, by which even bone and cartilage were rendered soft and eatable. Of what value the discovery has been to commerce it would be exceedingly difficult to say.

Probably this means of cooking and preserving food has had to be rediscovered, for more than one nineteenth century name is associated with the subject, and Tyndall's plan of "discontinuous heatings" does not suggest any reference to the Papin plan. Possibly we might not have had occasion to remember the "digestor" at all had it not embodied a principle of great value, altogether apart from the culinary art. To the digestor was first applied the safety-valve. Let John Evelyn, therefore, describe to us the occasion on which the famous scientific freak made its first public appearance. He has in his inimitable Diary for a day in March of 1682 the following quaint entry:

"I went this afternoon with severall of the Royal Society to a Supper which was all dress'd, both fish and flesh, in Monsieur Papin's Digestors, by which the hardest bones of beefe itselfe, and mutton, were made as soft as cheese, without water or other liquor, and with lesse than 8 ounces of coales, producing an incredible quantity of gravy; and, for close of all, a jelly made of the bones of beef, the best for clearness and good relish, and the most delicious that I had ever seene or tasted. We eat pike and other fish bones, and all without impediment; but nothing exceeded the pigeons, which tasted just as if bak'd in a pie, all these being stew'd in their own juice, without any addition of water save what swam about the Digestor, as *in balneo*; the natural juice of all these provisions acting on the grosser substances, reduc'd the hardest bones to tendernesse; but it is best descanted with more particulars for extracting tinctures, preserving and stewing fruite, and saving fuel, in Dr. Papin's booke, publish'd and dedicated to our Society."

Such was the contrivance for which the safety-valve, indispensable to the steam-engine, was invented. Papin secured due intensity of heat for his digestor by preventing the steam from at once escaping, so raising the temperature of the contents considerably above boiling-point. But his

experiments soon convinced him of the dangerous expansive properties of steam, and to prevent his cooking utensil from bursting he devised his safety-valve. This consisted of a small plate, or cylinder, fitted into an opening in the cover of the boiler, and kept shut by a lever loaded with a weight, capable of sliding along it in the manner of a steelyard. The pressure of the weight upon the valve could thus be regulated at pleasure. When the pressure of steam became excessive, the valve was forced up, and so permitted an escape of steam. The strange thing is that Papin, who had ingenuity enough to invent the safety-valve for his food-boiler, did not realise its value

A MODEL OF PAPIN'S DIGESTOR, SHOWING THE SAFETY-VALVE

for his steam-engine, but employed another expedient for the purpose. And the members of the Royal Society ate their meal of stewed meats without a glimpse of knowledge that a device of supreme importance to the future of mankind was incorporated in the mechanism of the digestor.

"Papin," Evelyn notes, "is since gone to Venice with the late Resident here (and also a Member of our Society), who carried this excellent mechanic, philosopher, and physician, to set up a philosophical meeting in that citty." The "philosophical supper," he says, "caused much mirth amongst us and exceedingly pleased all the company. I sent a glass of the jelly to my wife, to the reproach of all that the ladies ever made of the best hartshorn."

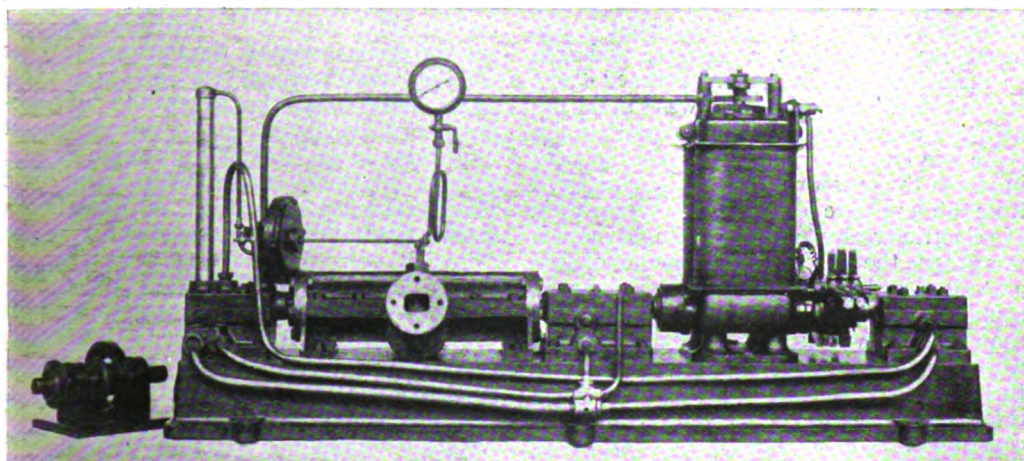
Papin remained two years in Venice, and on returning to London was appointed by the Royal Society temporary curator of experimentists, but in 1687 he accepted the Chair of Mathematics in the University of Marburg, passing thence, eleven years later, to Cassel. From time to time he communicated to his scientific friends in London news of his progress in physical experiments, but his most important papers are included in the Acts of the Leipsic Academy, among them, dated 1690, being one in which he describes his plan of developing mechanical power by the condensation of steam. This is entitled "A New Method of Obtaining Very Great Moving Powers at Small Cost." He had previously experimented with gunpowder, seeking by exploding it in a cylinder to cause a vacuum through which a piston would descend and, by depressing a beam, work a pump. Curious that one of the first men seeking a new prime mover should first try the internal-combustion engine which, left for another two centuries, has since revolutionised methods of travel.

But gunpowder was unsatisfactory. It was too violent in action, and did not produce a sufficiently good vacuum to enable the piston quickly to descend. Papin therefore substituted steam to raise the piston, and, upon condensing, to create the vacuum, leaving gravitation and atmospheric pressure to produce the downward or power stroke of the piston. But the engine was extremely crude, for each time the piston was raised the fire had to be withdrawn from beneath the cylinder to admit of the condensation of the steam. Thus his engine was not actually a steam-engine; it was an engine in which steam was generated in order that the forces of gravitation and atmospheric pressure might be utilised.

Papin's invention far excelled Savery's, for the latter simply relied upon the actual contact of steam with water for raising the latter. Papin's transmitted power by way of piston and connecting-rod to the beam above. In Newcomen's hands engines embodying pistons resembling Papin's became prime movers indeed, and pumped water from English mines for three-quarters of a century. Papin derived no advantage from his invention, but, returning to London in 1707, was coldly received. Without resources and practically without friends, he vanished from the haunts in which, twenty years before, he had been famous, and, it is supposed, died, in 1712, in poverty.

SIR CHARLES ALGERNON PARSONS
The Inventor of the Steam-Turbine

Charles Algernon Parsons, the greatest steam-engineer since Watt, was born in London on June 13, 1854. He is the fourth son of the famous Earl of Rosse, of Birr Castle, Parsontown, Ireland, who constructed the great reflecting telescope by which many astronomical discoveries were made. From his father and his father's friends Sir Charles derived the passion for scientific research which has had such large results. Sir Robert Ball, the brilliant astronomer, was one of his tutors, and, having the Rosse telescope at hand, Sir Charles was taught to use it, in the hope that he might, as he grew up, continue his father's work, and make the study of the stars the work of his life.

In order to get the knowledge and experience in practical engineering that he required, he entered the Elswick Works after leaving Cambridge, in 1876, and served under Lord Armstrong until 1881. He quickly distinguished himself by his inventive talent, and made a new kind of steam-engine of a rotary kind, in which the cylinders revolved. This was the principle afterwards applied in France to the Gnome petrol-engine used on flying-machines. But after joining Messrs. Kitson, of Leeds, and making an experimental model of a steam rotating engine, Sir Charles came to the conclusion that all steam-engines could only be improved into a greater economic efficiency by using steam power in an entirely new way.

A MODEL OF THE ORIGINAL PARSONS STEAM-TURBINE AND A HIGH-SPEED DYNAMO DRIVEN BY IT

But, as often happens, Sir Charles and his brothers were inclined to look on astronomy as task-work. More entertaining to them was the mechanical aspect of the great telescope. Taking up the study of mechanics, they built, while still but lads, a steam motor-car that ran at the speed of ten miles an hour. At nineteen Sir Charles Parsons went up to Cambridge, and laid the foundation of his future achievements by developing his talent for mathematics and coming out eleventh Wrangler. It was at Cambridge that the idea occurred to him that the ordinary steam-engine was constructed on a wrong principle. It seemed to him that all the mechanism necessary for transforming the straight to-and-fro movement of the piston-rod into the circular action of shafts and wheels was a pure loss of energy. The engine of the future, he argued, would have to be provided with a direct rotating action.

In 1884 he became a partner in the firm of Clarke, Chapman, Parsons & Co., of Gateshead-on-Tyne, and began his researches on the turbine principle. He aimed at using the steam in somewhat the same way as water is used in driving a modern water-wheel. It was not difficult to make a wheel fitted with a ring of vanes, against which a jet of steam played through a steam pipe from the boiler. The trouble was that the wheel went round so fast that no machinery could work at the speed. The movement was too quick, and at the same time the force of the movement was comparatively slight. It might do for churning butter, but it would not do for driving ships. Moreover, the steam had a cutting action on the metals used in the vanes of the turbine, so that the working part was quickly worn out. All these difficulties were overcome at last by constructing a large number of wheels of

different sizes, and fitting them together into a long compound turbine.

At the place where the steam entered the rings were comparatively small. Then, as the steam expanded and its pressure decreased, the rings became larger. New kinds of blades or vanes were devised, as the result of calculations and experiments, and the entire series of rings was covered in by an outer shell of metal, on the inner side of which were fitted lines of guide-blades that directed the steam on to the moving blades of the compound turbine. In this way Sir Charles Parsons distributed the power of the steam over a large working surface, and reduced the velocity of the result in movement while obtaining a larger output of working power.

The first Parsons steam-turbine, of ten horse-power, was made in 1884, but it ran at 18,000 revolutions a minute, and was so inefficient that it was nicknamed "the steam-eater." The speed was still too high for any ordinary purpose, but happily there was one important branch of industry in which the ordinary steam-engine suffered from an opposite defect. The generation of electricity by steam-driven dynamos was then the latest development of engineering, and it was found that a dynamo could be profitably driven at a higher speed than that at which a reciprocating engine worked. On the other hand, the steam-turbine moved round so quickly that when it was coupled to a dynamo it set up centrifugal strains that tended to break up the generator. Sir Charles Parsons was obliged to construct a special dynamo to run with this turbine, and this was a task that gave him almost as much trouble as the invention of the turbine itself. But by continually improving his new engine he managed to reduce the speed with which it whirled round, and to increase its output of power, until it was gradually developed into a more efficient prime mover than the ordinary reciprocating engine.

Just as Sir Charles Parsons was working out the problem of adapting his invention to driving steamers at a new and higher speed, another difficulty arose. The partnership with Messrs. Clarke, Chapman & Co. was terminated in 1889, and the rights in the turbine patents were held by the firm, and lost to the outgoing junior partner. Undauntedly, Sir Charles founded, in 1890, the now world-famous works of C. A. Parsons & Co., at Heaton, Newcastle, and with a band of brilliant fellow-workers he began to experiment on a new kind of turbine. It was not successful. But in 1894 Sir Charles managed to acquire the patent rights in his original invention, and by introducing improvements in his old turbine he was able to astonish the world.

He found that his engine drove the propeller of a steamer so quickly that much of the power was lost in maintaining an air-space round the screw, instead of pushing the water away and sending the ship forward. Tackling this new problem, he devised a new kind of propeller, and at the Naval Review in 1897 the tiny "Turbinia" attained the wonderful speed of 34½ knots an hour. The Admiralty then gave an order for a turbine-driven destroyer with a speed of 30 knots. When the vessel was tried it ran at the rate of over 37 knots, or about 43 miles an hour. The steam-turbine had arrived! Until an efficient gas-turbine is invented, the Parsons turbine will probably remain the most suitable prime mover for the generation of electricity. It is likely also to remain useful in driving vessels at a very high speed, though the Diesel engine, which requires a smaller space for its fuel, is becoming a serious rival in marine locomotion.

SIR WILLIAM PETTY

The Philosopher as Inventor

Sir William Petty was born at Romsey, Hampshire, on May 26, 1623, the son of a small shopkeeper. Educated at the local grammar school, he displayed marked talent for mechanics, and is said to have mastered, by the time he was twelve, the various trades practised in the town merely by watching the workmen at their tasks. It is curious that a boy of such tastes should have been sent to sea, but there he found himself, and in very bad company, for his shipmates deserted him on the coast of France, leaving him destitute, with a broken leg. He survived this misfortune, and managed to maintain himself, first as a pedlar and afterwards by teaching English and navigation! With characteristic courage he took advantage of his opportunity thoroughly to master French and to enter himself as a student at the Jesuit College of Caen, Normandy. Returning to England, he entered the Navy, but, being ill-used for inefficiency caused by his defective eyesight, he quitted the sea, and, returning to the Continent, managed to pursue his studies at various centres of learning, finally spending some time in Paris, where he made the acquaintance of several English refugees of note.

When three-and-twenty, he returned again to England, where he followed in his father's footsteps by engaging in trade as a clothier in a small way of business. At the same time he pursued his study of mechanical contrivances, and invented an ingenious letter-copying machine. He had qualified as a doctor of medicine at Leyden, but, his passion for learning remaining unabated, he now entered himself at Oxford University, where he gained his M.D., engaged in scientific speculation, and with one or two men of like mind began a series of meetings out of which the Royal Society was destined to spring. As in Paris, so at Oxford, he did a good deal of dissecting, was appointed a Fellow of his college, then passed over to Ireland as Physician-General to the Forces, where he effected sweeping reforms in the medical service.

While in Ireland, Petty carried out the first properly organised survey of the country. Forfeited lands were being parcelled out among the English soldiery, and to end the disputes as to areas and boundaries Petty undertook the survey by methods of his own. The work eventually developed into a map for the entire island, and this he caused to be printed, at a cost to himself, says Evelyn, of about £1000. He had, however, made considerable profits in Ireland, so that he was able to buy himself an estate of £4000 a year, while he received a valuable property near Limerick. At the Restoration Petty was deprived of all his appointments, but was soon reconciled to Charles II. and his brother, and at the incorporation of the Royal Society, in 1662, Charles knighted him. The Duke of York found him a valuable ally for his shipbuilding projects. His most remarkable invention in this connection was a double-keeled vessel, which Evelyn described as "flat-bottom'd, of exceeding use to put into shallow ports, and ride over small depths of water. It consisted of 2 distinct keeles, crampt together with huge timbers, etc., so that a violent current of water ran betweene; it bare a monstrous broade saile."

Pepys tells us of the exploits of this vessel in a race for a wager with the packet from Holyhead to Dublin, and of Petty's offer to race it against any ship the King possessed. "It is about thirty ton in burden, and carries thirty men, with good accommodation (as much more as any ship of her burden), and so any vessel of this figure shall carry more men, with better accommodation by half, than any other ship. This carries also ten guns, of about five tons weight. In their coming back from Holyhead they started together, and this vessel came to Dublin by five at night, and the pacquett-boat not before eight the next morning." The ship, which was named by Charles II. "The Experiment," was subsequently lost in the Bay of Biscay during a storm in which fifteen other vessels were wrecked; but Petty maintained that "the perfection of sayling lies in my principle, finde it oute who can."

Petty made many contributions to the learning of the time, although he could hardly have been encouraged by the fact that the King merely laughed at the notion of his and his associates in science wasting their time in "weighing of ayre." Among his inventions were a new form of land-carriage, a forerunner of the bicycle, and an abortive attempt at a steamship. He founded iron-works, opened lead-mines, started a fishery and a timber industry, advocated reforms in dyeing and woollen manufactures, and became famous as the foremost political economist of the day. Evelyn has left us a pleasing picture of the man who, in the midst of wealth and luxury which the tastes of his aristocratic wife demanded, would say "What a to-do is here! I can lie in straw with as much satisfaction."

The diarist says of his friend: "There is not a better Latine poet living when he gives himselfe that diversion; nor is his excellence less in council and prudent matters of state; but he is so exceeding nice in sifting and examining all possible contingencies, that he adventures at nothing which is not demonstration. There was not in the whole world his equal for superintendent of manufacture and improvement of trade, or to govern a plantation. If I were a Prince, I should make him my second counsellor at least. There is nothing difficult to him. He is besides courageous, on which account I cannot but note a true story of him, that when Sir Aleyn Brodrick sent him a challenge upon a difference 'twixt them in Ireland, Sir William, tho' exceedingly purblind, accepted the challenge, and, it being his part to propound the weapon, desir'd his antagonist to meete him with a hatchet or an axe in a dark cellar, which the other of course refused. . . . He never could get favour at Court, because he outwitted all the projectors that came neere him. Having never known such another genius, I cannot but mention these particulars amongst a multitude of others which I could produce. When I, who knew him in mean

circumstances, have been in his splendid palece, he would himselfe be in admiration how he arriv'd at it."

Petty died in London on December 16, 1678. His widow was created Baroness Shelburne. His two sons died childless, and the estate passed to his only daughter, who married Thomas Fitzmaurice, first Earl of Kerry, and was declared by a relative to have brought "into the Fitzmaurice family whatever degree of sense may have appeared in it, or whatever wealth is likely to remain in it." From this Earl of Kerry and William Petty's daughter descend the Marquesses of Lansdowne, who still preserve the family name of Petty.

PINCHBECK AND SON

Two Useful, Humble Lives

Christopher Pinchbeck was a Clerkenwell maker and repairer of clocks and watches, born about 1670. Practically nothing is known of his career, though through old printed announcements we can trace him here and there, from Clerkenwell into Fleet Street, in which latter thoroughfare he advertised himself as "inventor and maker of the famous astronomico-musical clocks," and announces that "he maketh and selleth watches of all sorts, and clocks, as well as plain, for the exact indication of time only, as astronomical, for showing the various motions and phenomena of planets and fixed stars." He invented clocks that played tunes, imitated the notes of birds, and furnished automata for providing music in churches. There is no doubt that his clocks exhibited great ingenuity of structure, and one which he made, at a cost of £500, for Louis XIV., is described as having been a particularly fine piece of work. An organ built for the Great Mogul brought him £300, a price which seems not to have been excessive for the article. It is an interesting commentary on the trading methods of the period that this talented man was wont to exhibit his wares at fairs, in conjunction with a conjurer named Fawkes.

Today his only claim to remembrance is that he invented the useful alloy called by his own name, Pinchbeck. This is a combination of copper and zinc, and was used for toys and timepieces. Pinchbeck is now a term of contempt; but the actual alloy, cheap and durable, and therefore despicable to the wealthy, was the first metal which allowed the poorer classes of this country to possess their own watches; and the combination that he employed has been fruitful in suggesting other alloys to men of more considerable reputation who have followed him. Pinchbeck the elder died on November 18, 1732. His second son, Christopher Pinchbeck, born in 1710, carried on the business founded by his father, and invented several useful contrivances, one of which was valuable—a self-acting pneumatic brake for use on cranes. He was a particularly skilful maker of astronomical clocks, and Ferguson, the astronomer, was pleased to work out the calculations for some of the wheels he employed. Pinchbeck the younger was a force to be reckoned with in the days of our grandfathers, for his were the candle-snuffers by which all the world snipped off the spluttering tower of red-hot wick that topped the burning tallow. He lived a quiet and useful life among his clocks and watches and musical automata and the alloy that his father had invented. Pinchbeck the younger died on March 17, 1783.

VALDEMAR POULSEN

The Danish Rival of Marconi

Valdemar Poulsen, the now famous electrical engineer of Copenhagen, first distinguished himself in 1899 by inventing a wonderful talking-machine. It is called the telegraphone, and it is designed for recording telephone messages, though it can be used as an ordinary sound-reproducer. It records the voice solely by the influence of electro-magnetism on a thin wire or a thin sheet of steel. As in a telephone, the sound-waves are transformed into a varying current of electricity. The current flows along a wire placed close to a disc or wire of magnetic steel. It magnetises the steel so that the steel is able to affect a magnet, and the magnet acts on the membrane of an instrument similar to an ordinary telephone receiver.

The membrane is a thin sheet of metal; and as it vibrates in answer to the force communicated to the magnet it sets up waves in the air that reproduce the sounds of the original speech. At present this magnetic phonograph that writes sounds in invisible electro-magnetic characters on a steel plate is somewhat too costly for general use. But it is not unlikely that the letters of our descendants will consist of a thin disc of steel carrying a spoken message, which will be repeated every time the disc is placed in a little transmitting instrument. Very thin metal sheets can already be made that are lighter than paper.

About the same time that the Danish inventor was making his telegraphone, an

Englishman, Mr. William Duddell, constructed an electric arc light that sang as it flamed. Duddell's singing arc consists of an arc lamp connected with an electric wire in the ordinary way. But the wire is broken, and a thing called a condenser is placed in the path of the electric current. This gives the current a kind of regular unsteadiness. The flame of the arc moves backwards and forwards between the carbon points, and this alternate movement makes it sing.

While the arc is singing, the electric discharge between the carbon points sets up electric waves that go rippling out into space. In 1899 Mr. Duddell found that he could obtain by means of his singing arc 40,000 waves a second. Then Mr. Poulsen took up the matter, and by immersing the Duddell arc in hydrogen, or coal-gas mixed with hydrogen, he obtained a million and more electric waves in a second.

This was the origin of the new system of wireless telephony and telegraphy which has recently attracted wide notice. By connecting a wire from a telephone to a powerful electric singing arc, Mr. Poulsen was able to speak from Denmark to England, for his electric waves were so numerous that they reproduced at the receiving station near Newcastle every inflexion of the human voice. Quite a low current was necessary to create a million vibrations a second. It is said that in America wireless messages have been transmitted for some thousands of miles by means of an improved instrument, in the construction of which Mr. Poulsen has been helped by another Danish man of science, Professor Pedersen. In the Marconi system the electric wave is created by a spark produced by a current of high voltage. The waves made by this method are too few to carry and reproduce all the subtle inflexions of the human voice. But only experience can show which of the rival systems is better suited in a general way for long-distance wireless telegraphy.

SIR FRANCIS RONALDS

The Inventor of Telegraphy

Sir Francis Ronalds was born in London on February 21, 1788, and from his youth up betrayed the liveliest interest in physical science in general, and electricity in particular. Like Nasmyth, he was early trained to correct draughtsmanship, a fact which led in later life to his inventing an ingenious perspective-tracing instrument of which he was not a little proud. But it is as the inventor of a real system of electric telegraphy, which was years too early for his times, that he remains known to fame. The nearest approach to an electric telegraph in existence when Ronalds began his work was Soemmering's, in which signals were emitted from twenty or thirty wires by means of bubbles of gas arising from the decomposition of water during the discharge of an electric current. As all these telegraph wires were of gold, it is needless to say that the instrument was as costly as it was impossible. Ronalds made an enormous advance when, in 1816, he fashioned an apparatus that transmitted every requisite signal with the use of only a single circuit. His current was obtained by means of a frictional electrical machine,

SIR FRANCIS RONALDS

and was conveyed through eight miles of wire, insulated in glass tubes, and surrounded by a wooden trough filled with pitch.

The method of signalling by pith-ball electrometer, though slow, was ingenious in the extreme. At each end of the wire was a sort of clock-face. Affixed to the seconds-wheel of each was a paper disc bearing all the letters of the alphabet and the ten numerals. Only so much of this disc was exposed at a time as to show a single letter or figure, this being displayed through a small opening as the wheels revolved. The clocks at the two ends of the wire were set exactly together, so that the same letter was exposed simultaneously at both ends. The sender, as a certain symbol appeared upon his disc, sent an electric signal along the wire, and the

signal, instantly received at the opposite end, indicated to the operator there the symbol intended. The installation was singularly well thought out, for as a preliminary to a message an electric shock discharged a small pistol to call attention and set the dial at the signal "prepare."

The whole idea was really admirable for a first attempt, and Ronalds, though he appreciated to the full the fact that this was but the first practical step, expressed the belief that he would live to see the day when the King at Brighton would be able to communicate by telegraph instantly with his Ministers in London. He did see his prediction realised, but not to his own profit, for his invention brought him an example of fatuous blindness on the part of the Lords of the Admiralty which has now become, in its own way, as famous as the invention which their lordships contemned. He was informed, when at last the Admiralty condescended to notice him, that, the war with France being then at an end, there was no need for telegraphs of any kind, but that in time of war no other than the one then in use, the semaphore, would be adopted. In the nineteenth century the Admiralty were still living in the spirit of Armada times, when

> The sentinel on Whitehall gate looked forth into the night,
> And saw o'erhanging Richmond Hill the streak of blood-red light—

when bonfires and beacons, and wooden telegraphs worked by hand, when the sun was up, sufficed to tell the news from coast to capital. So Ronalds, in his cheery way, bade "a cordial adieu to telegraphy" and went upon his travels, a wiser, though not necessarily a sadder, man.

His invention was not wasted. Wheatstone had seen it, and afterwards acknowledged that he had been greatly indebted to the cheerful savant telegraphing with might and main through eight miles of wire in his Hammersmith garden. Ronalds afterwards attained fame as a meteorologist, and devised a valuable system of photographic registration for meteorological instruments. The Government never quite forgave him for his having been wronged by them; and when, after many years' excellent service, he retired from Kew Observatory, they awarded him a niggardly £75 a year pension. When application was made to Lord Derby for some recognition, similar to that accorded to Wheatstone and Cooke, of the services of Ronalds to science the request was refused, but Gladstone was induced, in 1871, to bestow a knighthood upon him. Ronalds, who collected a valuable library of scientific works, died at Battle on August 8, 1873.

CHARLES LATHAM SCHOLES

The Founder of the Typewriting Industry

After Henry Mill, an engineer of the New River Company, took out a patent in 1714 for "an artificial machine or method for the impressing or transcribing letters, singly or progressively one after another as in writing, whereby all writing whatever may be engrossed on paper or parchment so neat and exact as not to be distinguished from print," there were many attempts to make a typewriter. One of the most ingenious of our modern men of science, Sir Charles Wheatstone, occupied himself with the problem from 1840 to 1860, and made several experimental models. About the same time, mechanics in France and the United States tried to design a practical writing-machine.

But it was a printer, with no experience in fine mechanical construction, who made the modern typewriter. In 1867 Charles Latham Scholes, of Milwaukee, Wisconsin, was working as a printer, and trying to devise a machine for printing in the number of pages in bound books. "If numbers, why not letters?" said a friend to him. Scholes thought out the suggestion. A number-writing machine was a fairly easy affair, as only ten signs were needed; to write the letters of the alphabet, and figures as well, there was required a larger and much more complicated mechanism. Scholes, however, had invented the most important part of the writing-machine—the spacing device; and his friend Carlos Glidden, who was an ironmonger of Ohio, became deeply interested, and, with another man, S. M. Soulé, entered into a partnership with Scholes for the development of the typewriter.

But when the first crude model was constructed, in 1868, Glidden and Soulé tired of the matter, but Scholes went on working out improvements. His chief trouble was that he was not a mechanic, and he did his work very roughly. The parts fitted badly and worked loosely just where combined strength and delicacy of craftmanship were of vital importance. Happily, Scholes found a man ready to bear the cost of continual experiment. Several models were built and tested and found wanting, until Scholes himself wearied of the task. But Densmore, his new backer,

was invincibly hopeful. He saw that the inventor was slowly working out, by the primitive method of trial and error, a sound design.

For instance, Scholes had begun with a keyboard like that of a pianoforte, but, finding it too heavy, he made the keys lighter and arranged them more compactly. He improved the action of the converging type-bars, and got the carriage to run more smoothly. By 1873, after thirty trial machines had been laboriously designed and still more laboriously constructed, the main principles of the modern typewriter had been toilfully discovered by the printer of Milwaukee. Almost everything of large importance was in the machine, but it lacked the fine workmanship and the exquisite and economical adjustment of parts which a watchmaker, for example, would have achieved.

This was pointed out by Mr. G. W. N. Yost when he was asked for his opinion on Scholes's last model. He said the machine looked as if it had been made by a village blacksmith. But the main lines of the design were sound; and for this reason Philo Remington, who had a small-arms factory at Ilion, in New York, took up the invention. Remington had prospered during the Civil War by supplying rifles to the Federal army, and he had brought out a breechloader of remarkable novelty and power. He was a man of inventive talent, with the special experience that Scholes lacked. A corner of his factory was given up to overhauling the design of the typewriter; and, after a year of patient improvement, the remodelled machine was, in 1874, placed on the market.

Naturally, it was still a primitive affair in comparison with the best machines of the present day. There was only a single type at the end of each type-bar; so the writing was done entirely in capital letters. And many of the modern ingenious devices for increasing the speed and the smoothness of working of the machine were lacking. But it was a great advance upon anything done by other inventors. It was a practical typewriter. It relieved a writer of some of the hardest part of the mechanical labour of writing, and journalists and literary men gradually found that the new invention assisted them in their work. Mr. Yost, who had been interested in the Scholes-Remington pioneer machine, was the first to produce a rival typewriter—the Caligraph. Then other American inventors brought out new varieties of mechanical writers, and as the competition grew keen the machines improved in quality and increased in number. Scholes made a new kind himself, in which the writing was visible to the operator, and this device has now been largely adopted by other makers.

ERNST WERNER VON SIEMENS

A Great Benefactor of Germany

Four sons of a farmer of Lenthe, in Hanover, the Siemens brothers, have each displayed so remarkable a talent in engineering, electricity, and other industrial sciences that the entire civilised world is their debtor. The inventions of the eldest brother, Ernst Werner von Siemens, are largely responsible for the great and rapid expansion of German industry. Born on December 13, 1816, Werner entered the Prussian Artillery at eighteen, after studying at Berlin, and at twenty-three the death of the father of the family threw upon him the cost of educating his brothers.

He was especially interested in electricity and chemistry, and by a stroke of good fortune was imprisoned for six months in a military fortress for taking part in a duel. Buying some electrical instruments, he turned his cell into a laboratory, and quickly discovered a method of electro-plating vessels with gold. He sold his idea to a jeweller, and bought more instruments. Then, to his dismay, the governor of the fortress entered with a Royal pardon. The fame of his invention had spread to the Court, and the King had immediately ordered him to be set free.

Werner had no place of his own he could turn into a laboratory, and he petitioned to be allowed to serve his full term of imprisonment, but this was not allowed, and he was ordered to proceed to Spandau and make some special fireworks for a festival in honour of the Empress of Russia. Owing to his knowledge of chemistry, he was able to produce some new and wonderful effects in the way of fireworks, and Prince Frederick Charles heard the amusing story of his imprisonment, and became one of his best friends.

Werner started an electro-plating business in Berlin to help his brothers, and entered the Ordnance Department to assist the Government in scientific work. His position in Berlin brought him into contact with many famous men of science; and, growing ashamed of his small inventions, he dropped all this kind of work, and devoted himself to deeper scientific study. Just as he was working out a new system of

telegraphy, he was banished because of his liberal opinions in politics. It was of great personal importance to him to remain in Berlin. So he invented a new kind of gun-cotton and sent it to the War Minister. It was so good that he was at once pardoned.

He had discovered that gutta-percha was an admirable insulator for telegraph wires. By covering a wire with this insulating material in a lead casing he made the modern form of cable. He also studied the curious way in which a current lagged in a cable, and devised means for overcoming this difficulty. An automatic recorder of telegraphic messages, and a system of using one wire for two or more messages, were among his other discoveries. He was the first man to use an electric wire for firing

MODEL OF A SIEMENS STEAM-ENGINE GOVERNOR

submarine mines, and a fort that he built against Denmark defeated a Danish fleet, sinking a battleship and capturing a frigate. In 1847 he laid the first long, underground cable from Berlin, and in the same year entered into partnership with Halske.

When his Government telegraphic work was finished, he left the Prussian Army, and devoted himself to electrical engineering. He built telegraph lines for the railways, and helped his brother Karl Wilhelm to lay the Atlantic cable in 1874; and in 1869 he constructed the vast telegraphic line running from Prussia to Persia. He invented one of the first dynamos, and built and ran in 1879 the first electric railway. Endowed with a profound inventive genius, he contributed more than any other man to the remarkable progress made by Germany in industrial electricity. In 1886 he gave half a million marks towards the foundation of the famous school of Scientific Industry at Charlottenburg. He died in Berlin, December 6, 1892.

SIR WILLIAM SIEMENS

A German Engineer who Helped England

Karl Wilhelm Siemens, better known as Sir William Siemens, was born at Lenthe, in Hanover, April 4, 1823. Helped by his brother Werner he studied at Göttingen University, and entered a factory in order to gain experience in engineering. Against his brother's wish, he resolved not to enter the Prussian Army, but to work as a civilian. He came to England at nineteen to sell Werner's gold electro-plating invention to Messrs. Elkington & Co., of London. The English firm had themselves discovered and patented an electro-plating system, and they told the young German that his brother's invention was simply an infringement of theirs. As a matter of fact, Messrs. Elkington had really anticipated the methods worked out by Werner Siemens. But Wilhelm, seeing at a glance the position of matters, replied that his brother used a thermo-electric battery. Messrs. Elkington wanted particulars. Werner invented the new kind of battery required, on receipt of his brother's letter, and £1400 was given by the English firm for it. On this unexpected sum the Siemens family were, for a time, able to flourish.

Karl Wilhelm was taken by the freedom and stir of English life, and, settling in our country, he acted partly as agent for his brother, and partly worked out inventions of his own. He had a hard time to begin with, for a differential governor that he and Werner designed proved to be an ingenious, excellent instrument that was not needed on a steam-engine. It was afterwards used in astronomical work. But the invention of a water-meter by Karl Wilhelm, in 1851, was a very profitable affair, and put an end to his monetary difficulties. In 1856 another Siemens brother, Friedrich, designed a regenerative furnace, and Karl Wilhelm helped him to improve it and make it an engine of revolution in glass-making, steel-making, and many other industries.

In this furnace the coal was placed in a producer, and turned into the gas now known as Siemens gas. The furnace was a kind of open hearth, over which the fierce flaming gas played, the gas being mixed with air to increase its burning power. In its gaseous

form the fuel was more easily controlled, and more efficient than when used in the solid shape of coal. But of more importance and originality were the regenerators which formed the original feature of the furnace. They consisted of chambers of brickwork through which the spent gases escaped. When these chambers were well heated by the escaping fumes, they were employed to warm the incoming currents of air and gas on their way to the furnace. The spent fumes were then directed into another chamber, till this also grew hot enough to warm the air and gas. By thus regularly changing the outlet and inlet of the furnace, much of the heat that was lost through an ordinary chimney was saved.

THE ORIGINAL DYNAMO DESCRIBED TO THE ROYAL SOCIETY BY SIR WILLIAM SIEMENS

Working out this idea with a British firm, Messrs. Martin Brothers, Karl Wilhelm developed a new way of making steel in a regenerative furnace with an open hearth. The Siemens-Martin process was started at Landore, in Wales, in 1857. The modern steel-built ship is one of the results of the Siemens-Martin process.

Karl Wilhelm also introduced, many years before this, the principle of using the spent fumes from an engine furnace to heat the steam on its way from the boiler to the cylinder. Though this idea was not fully carried out at the time, it has since proved of great importance in increasing the efficiency of steam-engines. In 1883 the English member of the Siemens family received the honour of a baronetcy. Some months after he died in London, on November 19, 1883. Like his older brother, Werner, he took an important part in the development of electric power, and was one of the first men to obtain a strong electric current from falling water by means of a water-wheel and a dynamo.

SIR FRANCIS PETTIT SMITH

The Struggle of an Idea

Francis Pettit Smith, inventor of the screw-propeller for steamships, was born at Hythe, Kent, on February 9, 1808, and, although betraying from an early age a marked talent for mechanical invention, particularly as applied to steamboats, began his career as a grazing farmer. As such, after an initial venture at Romsey, he settled down at Hendon, where he had the reservoir of the Old Welsh Harp for his experiments. It would be possible to cite nearly a score of names as pioneers of the screw propeller, but Smith had only one practical rival, Ericsson, and it is certain that he knew nothing of what other men had planned or attempted. Although in 1834 he made a successful working model of a little vessel driven by a screw which was actuated by a spring, and a year later

improved considerably upon this, it was not until 1836 that he troubled to patent the idea.

It was lucky for him that he did not longer delay, for Ericsson patented his own screw-propeller six weeks later. Smith, convinced of the value of his invention, secured financial support, and, soon after he had patented it, produced a little ten-ton vessel, with a six h.p. engine, with a wooden screw of two complete turns. During an early trial trip, the propeller struck an obstruction in the water, and knocked off half the length of the screw. The vessel immediately shot ahead at a much improved pace, and Smith was quick enough to realise the importance of the hint. He fitted the vessel with a screw of half the former dimensions, and away he went, down the Thames and out on a stormy sea, to Dover, Folkestone, Hythe, and home again, in the little ten-tonner that was to change the whole style of ship-driving.

The attention of those British mandarins the early nineteenth century Lords of the Admiralty was first drawn to the screw propeller by Ericsson, who got them aboard a vessel fitted with one, and so clearly demonstrated its superiority over the paddle-wheel that students of the history of the period will not be surprised that their lordships reported themselves "very much disappointed with the result of the experiment." Presumably they would have been satisfied with it only had it failed. Ericsson went off to America, and the field was left clear for Smith, as in poetic justice it should have been. But engineering opinion was against him.

The paddle-wheel had come to stay, they said. Sir William Symonds, an honest, pig-headed relic of other ages, averred that with a screw a ship could not be steered! As this gentleman happened to be surveyor to the Royal Navy, and hated steamships in general, and in particular denounced iron ships as "monstrous," Smith naturally had a difficult task to move the mountain against which his faith was pitted. The Admiralty asked for more evidence, and a little company was got together and built a wooden vessel. It was the "Archimedes," of 237 tons, equipped with eighty h.p. engines, and a screw propeller. Only five knots' speed was demanded by the Admiralty; the "Archimedes" did ten. She carried an Admiralty expert to all the chief ports in Britain, to Holland and Belgium, and to Oporto, across the Bay of Biscay. Brunel, who was building his iron steamship the "Great Britain," at the time, was so well pleased with the new scheme that he gave orders to convert her from a paddle steamer into one driven by a screw propeller. It is worth noting here that this vessel, the first considerable craft to adopt the screw propeller, was that which called into existence the famous Nasmyth hammer for a paddle crank-shaft that never came into being.

At length, in 1841, the first British warship with a propeller was laid down; but although she was of less than 900 tons, so lukewarm was the interest in her that her building occupied rather more time than is now allowed for a super-Dreadnought. And when she had satisfactorily passed all her trials, the Admiralty mandarins could not, would not, believe, until they had hitched her tail-to-tail with the paddle-steamer "Alecto," and set them to pull one against the other. As the "Rattler" hauled the other straightway into harbour, there remained not a shred of hope left to opponents of the reform, and twenty warships embodying the new idea were ordered, with Smith in charge of the business of fitting them with screws.

But he had not been allowed a bloodless victory. The little company formed to exploit his invention lost £50,000, and Smith, when his association with the Navy ceased, departed with so little in his pocket that he was glad to go back to the land and delve again for a living. Palmerston awarded him a £200 pension, and a place was found for him as a curator of the Patent Office Museum at South Kensington. Shipbuilders, learning of his losses and straitened circumstances, raised a subscription of between two and three thousand pounds for him, and, nearly a generation after he had established the success of his invention, he was knighted.

Smith wrought a revolution in shipbuilding of steamships greater than anything else achieved in relation to them. We could never have had our ocean liners of size and speed but for the indomitable will of this simple, grazing farmer. As Robert Stephenson said: "Mr. Smith worked from a platform which might have been raised by others, as Watt had done, and as other great men had done, but he made a stride in advance which was tantamount to a new invention. It is impossible to over-estimate the advantages which this and other countries have derived from his untiring and devoted patience in prosecuting his invention to a successful issue." Smith died at South Kensington on February 12, 1874.

JAMES STARLEY

Inventor of the Safety Bicycle

James Starley was born at Albourne, Sussex, on April 21, 1831, the son of a farmer, for whom he began work on the land at nine years of age. It was, however, not his ambition "to be a farmer's boy," and while in his early youth he tramped to London and gained employment, first as a gardener at Lewisham, and afterwards with a firm of sewing-machine makers. Having improved his master's machines, he made one of his own, and betook himself to Coventry, where his invention was manufactured by a firm created to exploit his idea. The same firm, for which he acted merely as managing foreman, carried out a succession of improvements effected in the bicycle by Starley. He did not invent the bicycle—the idea was old before Starley was born—but he made the machine one which could be ridden with comfort and with speed. The old "ordinary" evolved under his skilful hands. He gave the machine the small hind wheel, and the step on the backbone by which the rider mounted; he devised methods of steering undreamed of before; and he created the modern type of wheels.

Leaving his old firm, Starley formed a little company of his own, and for this invented the tricycle. History has records of other forms of three-wheeled contrivances for self-propulsion, but Starley's was the first real tricycle. The machine, enormously popular before the invention of the safety bicycle, as the modern cycle was originally named, has been almost entirely superseded by the two-wheeled machine, but part of its mechanism, the balance or differential gear, exists as a vital principle of the motor-car. The invention was Starley's. The back axle of the motor-car, like that of his tricycle, turns with the wheels. The differential gear allows one road-wheel to revolve more rapidly than its fellow when the car is turning a corner or meeting inequalities of the road. Starley's steering systems for the tricycle, too, paved the way for the motor-car engineer. The motor-car is the offspring of the tricycle and the gas-engine, and Starley, on the cycle side of the mechanism, is one of its ancestors.

Coventry owes to him entirely its proud position as the centre of the cycle and motor-car industry, for that industry followed where the cycle, with its army of expert engineers, had begun. Starley died at Coventry in June, 1881, and his memory is perpetuated by a monument in the town.

GEORGE STEPHENSON

The Founder of Railway Travel

George Stephenson was born at Wylam, near Newcastle, on June 9, 1781, the second son of a colliery engine-minder. His father earning but twelve shillings a week on which to keep a large family, the child was put to work when of very tender years. He worked as a herd-boy at twopence a day, a sum which he doubled by hoeing turnips and by other farm work before being taken into the colliery at fourteen years of age as assistant fireman to his father.

The housing problem in the North of England is not new; when George and his elder brother James were both at work as assistant firemen, the two younger boys as coal-pickers on the banks, and the two sisters were old enough to assist their mother with the household duties, the entire family —parents and six sons and daughters—lived and slept in a cottage of one room, with only the bare clay for floor. But in those surroundings the idea of the steam locomotive germinated in the brain of George Stephenson. It did not soon reach maturity.

A STARLEY SAFETY BICYCLE

Stephenson passed through various grades of work with colliery engines, and, the better to acquaint himself with their mechanism, he was wont to take them to pieces in his spare time, as a child dismembers a clockwork toy to see how the wheels go round. There was a good deal of knowledge concerning steam-engines in the world at this time, but it was beyond the reach of Stephenson, who could neither read nor write. He had nearly reached manhood before he first went to a village schoolmaster to be taught his three R's. When he first drew twelve shillings a week the honest fellow declared himself "made for life," yet, to supplement his modest earnings, he added the mending of boots and of watches and clocks to his labours. At twenty-one he

married a comely farm-lass, who, before she died, in 1806, became mother of Robert Stephenson, in whom the genius and virtues of his father lived again.

The first concrete evidence of the talent of Stephenson was manifested in his invention of the miners' safety-lamp. Almost simultaneously that of Sir Humphry Davy appeared, and there was a bitter controversy between the partisans of the two inventors as to which might claim priority. Of course, the two lamps were independently made, the same problem being solved on different lines. Stephenson, in 1818, received a public testimonial and a gift of £1000 in recognition of the merit of his invention. But much water flowed under the

GEORGE STEPHENSON

bridges between the perfection and recognition of the lamp; and in the meantime Stephenson had passed through dire poverty, its poignancy enhanced by the difficulty of educating his little son and supporting his now destitute father and mother.

It is interesting and suggestive to recall that at this time the man who was to enrich the world with the steam railway was drawn for the militia. Had he not been able to borrow £6 and buy himself off, he might have been sent as food for powder in a Continental war, when the world must have waited indefinitely for its railways.

While Stephenson was at work on his safety-lamp, the owner of the Wylam Colliery was seeking to introduce steam haulage into his mine. He was not successful, but Stephenson induced the proprietors of the Killingworth Colliery, where he was now engaged as engine-wright, to take up the problem, and for them he constructed, in 1814, his first engine, "My Lord." This ran along the tram-roads of the colliery, and hauled a thirty-ton load up an incline at the rate of four miles an hour. A second and third locomotive followed, and in 1815 he first applied the steam-blast, invented by Gurney. The locomotive engine became an established success from that hour.

Stephenson realised, as none of the other pioneers of the steam-engine did, that rails were necessary for the wheels of the engine; and when he learned that the project for connecting Stockton and Darlington by tram-road for the carriage of minerals had at last been sanctioned, he went to Edward Pease, the chief promoter, and laid before him a scheme for engines instead of horses. Pease eventually agreed, and Stephenson was appointed engineer of the line.

His gains from the safety-lamp now stood him in good stead, for with these, reinforced by the capital of Pease and partners, he was able to establish locomotive works at Newcastle.

The line was begun in May, 1823, and on September 27, 1825, was opened to the public. The train which inaugurated the service consisted of six waggons, carrying coal and flour, and one coach for passengers. George himself was the driver of the engine. A man with a flag, and mounted upon a a horse, undertook to patrol the line in front of the train; but Stephenson, after getting his engine nicely warmed up, "let her out," routed his flagman, and steamed off at fifteen miles an hour. He delivered his goods at Darlington, and returned, not empty, but with 600 passengers clinging like flies to his little train.

The abundant success of the Stockton line did not convince critics of the feasibility of the railway idea, but the history of the contest of conflicting interests, of the almost incredible opposition that he had to face when the Liverpool to Manchester line was mooted, of his famous cross-examination before Parliamentary Committees, of the trial and victory of the little four-ton Rocket, which did her thirty and more miles per hour, of his building the line across the formidable Chat Moss, and of the triumphant opening of the railway on September 15, 1830—all this is the familiar history of the school-book.

In all the railways that followed, Stephen-

son, until his withdrawal from business, was either engineer or expert adviser. He gave Europe the first of her lines. Sternly setting his face against the railway mania, he lived to see systems radiating in all directions from the parent lines which he had established. Riches came to him, and he was able, during the last few years of his life, to enjoy ease and leisure, with his son already as famous as himself as a maker of engines and builder of railways. Stephenson, who to the end of his days retained the engaging simplicity and unfeigned modesty of his early years, died at Tapton House, near Chesterfield, on August 12, 1848.

ROBERT STEPHENSON
Builder of Bridges

Robert Stephenson, only child of George Stephenson, was born at Willington Quay, near Newcastle, on October 16, 1803, and grew up to be at once the friend and comrade of his father and his co-pupil. To educate his boy the elder Stephenson mended clocks and shoes and made lasts for the local cobblers; he cut out the clothes that the boy wore, and turned a further honest penny by acting as cutter-out for the clothes of the colliers, which their wives made up. When Robert, aged twelve, rode daily to and from Newcastle, whither his father sent him, mounted upon a donkey, to school, it was in a suit of clothes of his father's fashioning. George had the lad made a member of the Newcastle Literary and Philosophical Society, and the learning that Robert gleaned there during the day he would impart to his incomparable father at night; and while Stephenson senior would do his best to instruct his fellow-pitmen in the mysteries of the earth's rotundity and the laws of gravitation, little Robert would seek to induct them into the intricacies of algebra.

When he was sixteen Robert was apprenticed to the under-viewer of the mine, and served three years to the mysteries of managing a colliery. Then his father sent him off for a three years' course to Edinburgh University. In order that his father might share his advantage, Robert taught himself shorthand, took verbatim notes of all the scientific lectures he attended, and upon his return home during vacations faithfully read them over to his sire. At the end of his university course he assisted his father in surveying the Stockton-Darlington line, in establishing the Newcastle factory, and in the preliminaries of the Liverpool to Manchester venture. A breakdown in health caused him to accept the offer of a situation in Colombia, where he had charge of gold and silver mines. Hearing, however, from Pease that the Newcastle factory had fallen upon evil days, he set out for England, intending to carry out on the way a rough survey of the isthmus of Panama, with a view to testing the practicability of cutting the canal for which the world has had to wait until 1913. He did not reach Panama, but he had the good fortune to meet Richard Trevithick, returning penniless from a mining venture, and to be able to lend him £50 to get home. The ship by which they journeyed was wrecked, but eventually Stephenson reached England, and, hurrying to Newcastle, arrived in the very nick of time.

He swiftly sorted out the tangle into which affairs had degenerated through the absence of himself and his father, and was able to lend the latter exactly the assistance needed for perfecting the Rocket in readiness for the historic trial of rival locomotives. It was an opportune arrival indeed, for when Robert set foot in England the only other man in the country who was seriously advocating steam locomotive-engines for the Liverpool and Manchester Railway was his own father. Those who did not cry out for horse-power, or for greased roads with cog-rails, demanded atmospheric-engines, or power from compressed gases or stationary engines. Of course, there was no looking back after the Rocket's trial. Robert comes prominently into the history of that famous engine. It was constructed under his supervision, and he worried out the plan of the fire-tubes by which she got her greater power and speed. Thereafter, practically all the improvements in the Stephenson engines came from Robert, who, after assisting his father in the construction of one or two of his lines, became a railway builder on his own account, and gave us, in the London and Birmingham system, the first railway to enter the capital.

Stephenson became famous as a builder of bridges. He himself invented the system upon which the tubular plate bridge for the Menai Straits was constructed. It was in its time one of the world's wonders, and upon the strength of it he built a still greater, over the St. Lawrence, at Montreal, which at that day was the longest bridge in existence. Other of his bridges were the Conway, the High Level at Newcastle, and the Border Bridge at Berwick. Although he rarely spoke, save upon engineering matters,

Robert Stephenson was elected to Parliament for Whitby, which seat he represented for the last twelve years of his life. The fine story of the affectionate relations between George and Robert Stephenson has its parallel in those subsisting to the end between the Brunels. The two younger engineers crossed swords in amicable professional duels, and in Robert Stephenson the younger Brunel found his stoutest, and successful, rival, in the opposition to his temporary affection for the atmospheric railway, and in the battle of the gauges.

But there was a kink in even Robert Stephenson's well-trained mind. The Suez Canal had no more formidable opponent than the talented engineer who helped to give the railway world its railways, and

ROBERT STEPHENSON

who wanted to cut a canal through the isthmus of Panama. Robert Stephenson, whose health was probably undermined by his experience of Colombian fevers, died, in his fifty-seventh year, at his house in London, on October 12, 1859.

WILLIAM SYMINGTON
The First Practical Steam Navigator

William Symington, inventor of the first practical steamboat, was born at Leadhills, Lanarkshire, in October, 1763, and, being intended by his father—a miller with a bent for mechanics—for the ministry, was educated at Glasgow and Edinburgh Universities. The son, however, had a greater inclination for mechanical invention than for the pulpit, and engaged himself as mechanic at the Wanlockhead Colliery, in Dumfriesshire. With the assistance of his brother, Symington fashioned a steam-engine for road locomotion, and while in Edinburgh, trying to arouse interest in the invention, met Patrick Miller, of whose experiments with a boat which should be propelled by paddles mechanically operated, instead of by oars, we have already read in the lives of Henry Bell and Robert Fulton. Symington suggested his steam-engine as the prime mover, whereupon Miller built a boat, and in it installed one of Symington's engines.

In October, 1787, the grand experiment was tried with success upon Miller's private lake. The engine drove the paddles by means of chains and ratchet-wheels, and Miller was so well satisfied with the performance of the small boat that he had a second and larger constructed, for which Symington designed much more powerful engines, but upon the same plan. Not until these experiments had run their course, and the boat had developed a speed of seven miles an hour, did designer and owner realise that the chains and ratchet scheme was too clumsy for a boat. Miller drew out, hard hit financially. Symington went on and found a new patron and a new method.

The new friend was Lord Dundas, Governor of the Forth and Clyde Canal, and for him Symington constructed a steam-boat in which the power of the piston was delivered, by a connecting-rod, directly to the paddle-wheel shaft. Details have since been improved, but the principle still holds good for all paddle-steamers today. It was for Lord Dundas that Symington built his famous "Charlotte Dundas." Henry Bell, the future father of steam navigation in Europe, was engaged in the task of building the boat. Robert Fulton was a passenger during one of the vessel's trial trips, had her mechanism explained to him by Symington, and carried the idea across the Atlantic to embody in his first successful vessel, the "Clermont."

The "Charlotte Dundas," steaming against a strong wind, towed two heavy barges a distance of nineteen miles in six hours. Symington's success seemed assured when the Duke of Bridgwater ordered eight of his vessels. But the Duke died before the order could be executed; the canal company decided that the wash from the little steamer would destroy the banks of their waterway, and Symington's dreams were tragically shattered. The first practical

steamboat was laid up, and allowed to rot upon the banks of the canal. The inventor wandered in poverty to London, and there died on March 22, 1831. Bell and Fulton reaped where Symington had sown, but the glory of the unrequited inventor, once revealed, can never be dimmed.

WILLIAM HENRY FOX TALBOT

A Pioneer of Photography

William Henry Fox Talbot was born at Lacock Abbey, Chippenham, Wiltshire, on February 11, 1800, and, following Harrow, had a distinguished career at Cambridge University. He sat for Chippenham in the first reformed Parliament, and was a distinguished contributor to the scientific literature of his age, dealing with mathematical problems, optics, astronomy, and archæology. It was his proud distinction to be, with Rawlinson and Hincks, one of the first to decipher the cuneiform inscriptions on the monuments and other objects unearthed by Layard and Rawlinson at Nineveh, and so to unlock to the world the vast treasury of Assyrian lore and learning. Chief of his claims to fame, however, is the part he played in the invention of photography. Like the telephone and telegraph, photography occupied the attention of several men simultaneously. While Daguerre was experimenting in Paris, De Niepce was groping towards success at Chalon-sur-Saone, and Talbot was slowly evolving the sensitised paper negative.

The full story of the invention, and the part he played in it, will be found at page 3486 of the present work. Talbot carried on his experiments amidst delightful surroundings at Lacock Abbey—"a paradise," as Sir David Brewster wrote; "a fine old abbey, with the square of cloisters entire, fitted up as a residence, its walls covered with ivy, and ornamented with the finest evergreens." Here at times the leading men of science of the age would gather; and, as Brewster noted, "the only stranger is Tom Moore, a most delightful person, full of life, humour, and anecdote." From his ivy-clad paradise Talbot obtained some of his first photographic results, and sent them to Brewster, in whose family they were treasured for many years—picturesque bits of the old cloisters, leaves, printed pages from the library, lace from the treasures of the wardrobe.

Once he had gained his first success, Talbot made rapid improvements in photography, securing instantaneous pictures, and rendering them permanent with a gloss of his own devising. He patented his inventions, but afterwards gave all to the world, save the right of portrait-taking for sale to the public. Although the simultaneous appearance of the daguerreotype and Talbot's process led to inevitable disputes and jealousy, Daguerre's own countrymen handsomely acknowledged the English scientist's invaluable inventions by presenting him with a gold medal at the Paris Exhibition of 1867. Talbot, who was a member of the Royal Astronomical Society, a Fellow of the Royal Society, and a Royal and Rumford medallist, died at his home on September 17, 1877. He published serially, between 1844 and 1866, the first book ever illustrated solely by photographs.

NIKOLA TESLA

Pioneer in Transmission of Electrical Power

Nikola Tesla is the man of mystery in the modern science of electric wave applications. Many persons regard him as a charlatan of genius, since he announced in June, 1900, that he had discovered how to transmit a large electrical force over hundreds or thousands of miles without the use of wires. There were two grounds for the supposition. In the first place, Tesla brought into his article, which appeared in a popular magazine, a considerable amount of pure imagination. He attributed, for instance, to the inhabitants of Mars certain vague electrical disturbances which are traced on the receiving instruments of wireless telegraph stations. In the second place, he announced his discovery of stationary electric waves without fully divulging his methods of experiment.

He wanted, no doubt, to keep his patents rights, in a manner common among ordinary inventors, but unusual among men of science of the best school. So the physicists who would have helped to develop his ideas if they had been fully published were inclined to regard him with doubt. They held that, as his new electrical experiments were conducted from an entirely commercial point of view, they must be judged entirely by their commercial success.

Nikola Tesla comes of a Servian family settled in Smiljan Lika, in Austria-Hungary, where the inventor was born in 1857. His father was a clergyman in the Greek Church, and he wished his son also to become an Orthodox priest. The boy graduated at sixteen, but, instead of entering the Church, pursued the study of electrical engineering, and mastered several languages. He obtained a position of assistant engineer in

the Government Telegraph Engineering Department, and soon distinguished himself by working out some small practical improvements in telegraphy.

But Budapest did not at that time offer a field of opportunities in electrical industries large enough to attract him. So he went to Paris, and obtained employment in an electric light company. He met there some Americans, and learnt from them that there were larger chances for an electrical engineer in the United States. Tesla at once sailed for New York; and on the day he landed he set out to find the laboratory of Edison, and offered his services, and was made a member of the staff.

The experience he gained in working under Edison was of great value to him, but he was a man of too enterprising a character to remain long in a subordinate position. He made money, and was at last able to set up a laboratory of his own. Soon he made his name in connection with the generation of electricity at the Niagara Falls. The chief difficulty was to transmit the electric power over a considerable distance without losing much of the current. To do this it was necessary to turn a slow, broad flow of electricity into a thin, swift stream of power. An instrument devised by Tesla, and called a transformer, effected this change, and turned the low-pressure current into a high-pressure current. Later on, the Tesla transformer became one of the fundamental parts of the machinery in the production of the electric waves used in wireless telegraphy.

The trouble with regard to the present reputation of the famous Servian inventor is partly due to the fact that he is a curious mixture of an imaginative poet, a keen man of business, and an ingenious man of science. A first-rate authority on wireless telegraphy, Mr. James Erskine Murray, has courageously stated that he believes in the new kind of stationary electric waves that Tesla is still working on. Tesla says he found them while experimenting with wireless telegraphy during the season of thunderstorms. The waves, he said, were produced by the electrical discharge in the atmosphere that created the lightning flash and gave rise to the rolling thunder. He contends that, by transforming an ordinary electric current in some remarkable and mysterious way, he can produce a powerful electric wave, say, a thousand miles away from his transmitting station. In other words, he can produce stationary electric waves of great power at any given point on the surface of the earth. He claims that the force transmitted is so strong that it can work machinery. But as he has not, after thirteen years' work, made a commercial success of his discovery, it is impossible to judge its importance.

The poet in him has no doubt allowed his imagination to riot among the vaguest possibilities of this new electric force, while his keen, money-making instinct has prevented him from inviting fellow-workers in all parts of the world to collaborate with him in developing the use of the new waves. This is what Hertz did in similar circumstances, and what Tesla would have done had he remained in his native country and won some professorship in Croatia or Bohemia; but, having become an American inventor, he will not give away an idea that may bring in him money, and he remains at present content with the kind of fame bestowed upon him by American reporters of the sensational school.

RICHARD TREVITHICK
Pioneer of Steam Locomotion

Richard Trevithick, a pioneer of the steam locomotive, was born at Illogan, Redruth, Cornwall, on April 13, 1771, the son of a mine manager of considerable skill in mechanics. Steam locomotion and Trevithick were in their cradles in the same age. Newcomen's atmospheric engine had long been at work in Cornwall; Symington was experimenting with his steam-carriage in Scotland; Watt was investigating the properties of steam through the agency of one of Papin's steam cookers or digesters; Murdock was making a little steam-engine travel over the roads of Redruth; and when Trevithick was but six years old an ingenious Philadelphian, Oliver Evans, had actually secured a monopoly from the State of Maryland for the right to construct and run steam-carriages on the public roads. Before Trevithick got seriously to work, the Boulton and Watt engines were well established in Cornwall, and the best of Cornish brains were directed to the task of circumventing the patents. It was trying for Watt, but all for the good of invention.

Three-and-twenty years divided young Trevithick and William Murdock, but there was much in common between the two. Murdock, generous and hearty, did not hesitate to thrash a bully; and Smiles had it positively from a son of the Scots genius that the latter fought a duel with Trevithick's father on account of some ungenerous act on the part of the latter towards Watt. Be that as it may, it is

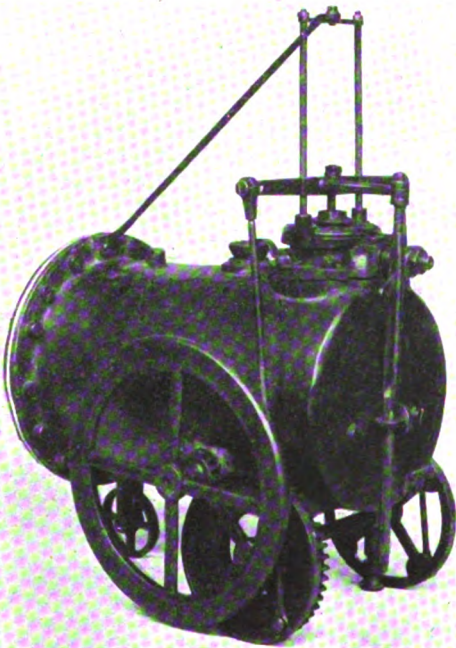
certain that Richard and Murdock had no quarrel; and it was from his experience of the older man's little steam-carriage that Trevithick devised his own first locomotive. Before that, however, he had greatly improved upon the stationary engine and the pump; and as soon as the Watt patent expired, in 1800, he built an effective, double-acting high-pressure engine with a crank, which was at once adopted for raising ore and refuse from mines. Earlier experiments with steam-carriages were now followed up, and led to the production, at the close of 1801, of the first vehicle of the kind by which passengers were ever carried.

In this engine the piston was not only raised, but was also depressed by the action of the steam. The steam was admitted by one port to raise the piston, then shut off at the top of the stroke and allowed to escape into the air, while a second port opening admitted a fresh draught of steam for the down-stroke. The only difficulty was that, in spite of bellows, Trevithick could not maintain draught enough to keep the engine supplied with steam. Trevithick conveyed his engine by ship to London, and patented it, taking care to indicate that the engine might be used upon tram-rails. He exhibited his invention in town until it met with a slight accident, when it was dismantled, and set up as a stationary engine at an iron foundry.

Trevithick's next venture in the like direction was made at Pen-y-darran, South Wales, where he was engaged to erect a forge-engine. Here tram-rails for waggons in which minerals were drawn by horses existed, and upon these Trevithick determined to try a locomotive. The latter was built in the company's forge, and turned out complete within a year; and on February 22, 1804, it ran its first journey, hauling seventy men and ten tons of iron, carried in five trucks. Soon afterwards it drew a load of twenty-five tons. The engine had but one cylinder. The motion of the wheels was produced by a spur-gear, to which was added a fly-wheel on one side to secure a rotary motion in the crank at the end of each stroke of the piston. The steam was carried, by way of a tube, into the chimney. On the strength of the latter contrivance it is claimed that Trevithick was the first to use the steam-blast for his boiler. Smiles discounts the claim, with the remark that the inventor simply turned his steam into the chimney in order to get rid of the nuisance caused by throwing the jet into the air. As against this we have Trevithick's letter, written at the time, to Davies Gilbert: "The steam is delivered into the chimney above the damper. . . . It makes the draught much stronger by going up the chimney." But he did not realise how vital the pinciple was, for he used bellows for increasing the draught, and, eleven years later, took out a patent for a system of fanners for enhancing combustion. There can be little doubt that the true steam-blast was the sole invention of Goldsworthy Gurney, and that George Stephenson's was the first reasoned application of it to the purpose of the locomotive furnace. Even the uncannily astute Ericsson used fantastic bellows for his engine in the famous Redhill trials—and was beaten by reason of their breakdown.

RICHARD TREVITHICK

Trevithick's engine never got a really fair chance. The public highways were too vile for the success of his road-carriage; the tram-lines were too fragile for his railway engine, which smashed the rails and finally toppled over, never to run again, although it worked for many years as a stationary engine. But, primitive as it was, Trevithick's was truly the first railway locomotive ever built. It was an unsuccessful copy of Trevithick's locomotive, established at Wylam colliery, that Stephenson first saw and improved upon. Trevithick built another locomotive, and

ran it as a sort of steam roundabout on the site of what is now Euston Square, London, but an accident to the engine disgusted him, and he did no more in the matter. Thereafter he devoted himself to improving stationary engines, and effected considerable technical advances; tunnelled the Thames for three parts of its distance before meeting with disaster; improved the shape and composition of boilers; fashioned the first of steam agricultural implements; went out to Peru to work silver-mines with his engines, and was ultimately brought by a revolution to utter ruin. After an adventurous journey home, already alluded to in the biography of Robert Stephenson, he reached England, and ultimately settled down at Dartford,

TREVITHICK'S MODEL OF HIS ROAD-LOCOMOTIVE

where he died, at the Bull Hotel, seriously in debt, on April 22, 1833. Only the generosity of the mechanics with whom he had worked at Messrs. Hall's establishment saved him from a pauper's grave. Trevithick was, in expert opinion, one of the greatest inventors of all time, but through lack of a good biographer his fame has been overshadowed by that of men less able.

ALESSANDRO VOLTA
The Discoverer of the Electric Battery

Alessandro Volta, the father of modern electricity, was born at Como on February 18, 1745. He belonged to an old, noble family of Milan, which had lost most of its wealth and power in the general decadence that followed the brilliant age of the Renaissance. Volta, like many Southerners, came to intellectual maturity at an earlier age than Northerners of genius. When but a boy, he was remarkable for the brilliance and versatility of his mind; and after hesitating for some time whether to become a poet or a man of science he devoted himself to the study of electricity at eighteen, and after some years of work brought out a new theory of the Leyden jar, and designed an electrical apparatus.

This work made his reputation, and in 1774 he was appointed professor of physics at Como. He invented more electrical instruments, chief among which were two kinds of apparatuses for generating electricity by induction. His fame spread through Europe, and he travelled with it to France and England in order to make the acquaintance of other students of electricity, and find what new work was being planned in his special science. But it was in his own country that he discovered the inspiration for which he was seeking. Galvani, a professor of anatomy at Bologna, thought he had discovered a sort of animal magnetism in some experiments with frogs' legs. Volta took the matter up, and showed that the copper skewer and the iron railing, used by Galvani in his experiments, were the sources of the electric current that acted on the nerves of the dead frogs.

By clarifying the problem in this manner Volta was able to ascertain that electricity could be generated by chemical means. It took him eight years to work out fully his new instrument for the generation of electricity. At the beginning of the nineteenth century the only way that men knew of making an electric current was by rubbing some non-conducting material. Electricity was made and studied by means of friction machines. The currents so produced were interesting from a scientific point of view, but they had little or no bearing on the conditions of modern civilisation. What was needed was some easier method of generating electricity. This Volta discovered by placing a piece of zinc and a piece of copper in a vessel filled with acidulated water, and connecting the two metals together with a wire. Thus was made the famous voltaic cell. By combining several of these cells together an electric battery was formed, which, like a battery of guns, produced a more powerful

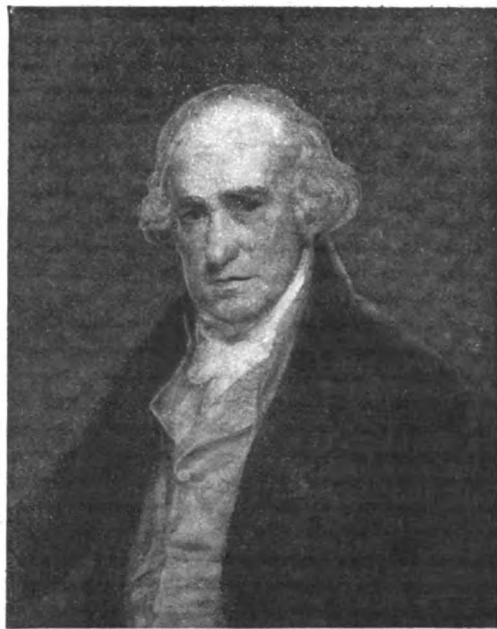
effect than a single electric cell. No matter how large a single cell is made, the pressure scarcely increases. If a large pond were cemented and filled with a solution of sal-ammoniac, and if two vast sheets of zinc and carbon were placed in it and connected with a copper wire, the pressure of the current so obtained would be almost as feeble as that produced in a cup of ammoniated water containing a small disc of zinc and a small disc of carbon. It is by connecting small cells into batteries that a powerful current is formed. The zinc in one cell is connected by a wire with the carbon in the next cell, while the zinc is connected with the carbon in the cell on the other side; then, from the wires running from the two end cells, a strong current can be obtained. The zinc wears away as the current is generated, but an unusually large amount of electrical energy is obtained from a pound of this metal by modern methods.

If only zinc were as cheap as coal, or if coal were as convenient for use in a battery as zinc, no ordinary fires or furnaces would now be used. The electro-chemical way of generating energy which Volta discovered would supply all the power needed in modern civilisation. Perhaps a positive coal or carbon battery will one day be perfected, but at present the difficulty of finding some cheap and common element to act with coal prevents this extraordinary development of the voltaic cell.

Volta may be said to be the founder of modern electric sciences and industries. He supplied the continuous electric current by means of which the magnetic needle of the electric telegraph was made to move. He first domesticated the most subtle and fundamental of natural forces. The greatness of his achievement was immediately recognised. In 1801 Bonaparte called Volta to Paris in order to see his experiments, and nominated him Count and Senator of the Kingdom of Italy. Volta resigned his professorship three years afterwards, feeling too fatigued in mind to go on with his work. He published nothing else of importance, and died at Como on March 5, 1827.

JAMES WATT
Inventor of the Real Steam-Engine

James Watt was born at Greenock on January 19, 1736, the son of a merchant shipowner who became chief magistrate of his town, but, in the boyhood of his son, had his house searched for runaway Prince Charlie during the '45 rising. Watt, as a delicate child, received his early education at home, where he showed striking manipulative skill with tools, and considerable talent for drawing. The story of his indulging in infantile speculations over the tea kettle as to the nature and properties of steam is shown by his most sympathetic and eulogistic biographer to be nonsense. Watt knew nothing of the mystery of steam until he had reached manhood, and had learned from Joseph Black the doctrine of latent heat.

At school Watt's schoolfellows made his life a misery. Delicate and weakly, he could not join their rough games, and the boys treated him as young hooligans of our own day are sometimes permitted to treat boys unfitted by constitution or temperament for

JAMES WATT

the hurly-burly of strenuous physical effort. Not until he reached subjects in school for which he had aptitude did he show the remarkable mental powers he possessed. He proved himself an apt scholar when he came to geometry, to Latin and Greek, and afterwards became proficient in French and Italian, but it was in modelling that he exhibited greatest skill; and it was his sure and delicate touch and correctness of work in this direction that led to his being put to learn the trade of a maker of mathematical instruments—most exact of craftsmanships.

After a brief spell in Glasgow he was sent to London to learn his trade of a good man

at the business in Cornhill, but a year of London atmosphere was as much as his feeble health could stand, and he returned to Glasgow and attempted to start in business for himself. The Glasgow Hammermen's Guild, however, opposed him, on the ground that he had not served an apprenticeship to the trade, and his prospects were very uncertain until friends at the university took him under their wing, and appointed him instrument-maker to the university. It was in this capacity that, in 1764, he received for repair the famous model of the Newcomen engine with which his experiments began. Then it was that he first bent his energies to mastering the problem of the steam-engine as a prime mover, not when he sat, an idle, thoughtless child, dreaming over the family tea-kettle. The story of his work in connection with the steam-engine is fully told at page 3605 and subsequent pages of this work, and the ground need not be covered afresh. Here we may note his partnership with Matthew Boulton, and removal to the famous Soho Works at Birmingham, where his steam-engine was evolved. Details of that historic partnership, so fruitful of benefit to British invention and industry, appear in the biography of Boulton at page 4436, and both men come into the life-story of William Murdock.

The asociation of Watt and Boulton was most fortunate. Boulton had long been experimenting with a steam-engine of his own, but along wrong lines. Watt brought him the idea which his capital and his fine works were available to develop. Without Watt, Boulton could have had no substantially improved engine to put upon the market. Without Boulton, Watt could not have raised the funds necessary to enable him to carry on his work. As a fact, the most important invention of his life, his condenser, remained two years unpatented owing to his lack of funds. He could raise no money in Scotland, and he could find no competent workmen there. He and Boulton perfectly complemented each other, and Boulton was one of the few men who could have kept the nervous, sensitive, suffering inventor on his legs. They took the model of their engine from Cornwall, and they improved it from an atmospheric-engine into a steam-engine. Resident Cornishmen, unwilling to pay for an improvement of the Newcomen product, did their best to profit by the Watt engine without paying royalty, and to do so they invented new device after new device to hide their piracies. Out of evil good resulted. The Watt engine was a standing challenge and temptation; and from the attempts to better and defeat it came engines which carried steam-power-raising ahead at a rate never before approached.

When Watt began work on the ineffective Newcomen model at Glasgow University, the steam-engine was simply a pump; when he died, Trevithick had had two locomotives engines at work, and George Stephenson had been for two years running his first locomtotive, named My Lord, hauling loads of coal at Killingworth Colliery. All this progress was covered by half the years of one whose life linked "the '45" with steam locomotion. Watt was the man to make it possible. He did not build, although he did plan, a steam-carriage, and he discouraged rare William Murdock from a similar pursuit. But Watt's engine made all things possible. It was not until his patent rights expired in 1800 that the others could come in without restriction. There is a tendency, owing to the abundance of data available as to the career of this remarkable man, to overrate his work, a circumstance which has driven some writers to the opposite extreme. He is spoken of as the creator of the steam-engine. Technically he is, but the term conveys a false suggestion to the forgetful mind. It ruthlessly ignores Papin, Savery, Newcomen, and others. They built steam-engines which technically were not steam-engines, but atmospheric-engines. They employed steam to raise a piston, then let gravitation and atmospheric pressure do the rest. Watt made steam raise the piston and deliver the return-stroke as well, so that his truly was the first steam-engine.

His inventive talent displayed itself in many other directions. He built a noble organ; he invented a machine for accurately reproducing copies of sculptures; he gave us the letter-copying press. He was a first-rate chemist, and seems, independently of Cavendish, to have discovered the composition of water. He invented an apparatus for the manufacture of gases; another for proving the specific gravity of fluids; a micrometer; anticipated a vital principle of the motor-car, by what we should now term a change-speed gearing for the use of steam-carriages on hills, and suggested a screw propeller or spiral oar, as he called it, for steamships. A man of sound scholarship, he was the recipient of many scientific distinctions, and patriotically refused offers to establish himself in France and Russia. He died at Heathfield Hall, near Birmingham, on August 19, 1819.

SIR CHARLES WHEATSTONE

Measurer of the Pace of Electricity

Sir Charles Wheatstone was born at Gloucester in February, 1802, and learned the trade of his father, a maker of musical instruments, but at twenty-one was placed with his uncle, a London music-seller. He was, however, always more interested in science than in business, and had been but a few months in London when he published his first paper on acoustics—" New Experiments on Sound." This, like his subsequent writings on the undulatory theory of light, he illustrated by a number of ingenious models, which have since played an important part in educational work. In the transmission of sound he made many delicate and beautiful experiments. One involved the use of a piano in an upper room, from which the tones travelled silently through the floor, down a wire, to become audible in a lyre depending from a cable in the hall below. In another, rods of wood passed from a cellar to a lecture-hall above. Each rod was connected with a separate instrument played in the cellar, while the melodies, conducted by the rods, reproduced themselves on the sounding-boards of three harps, which thus seemed to play themselves. Wheatstone would have made his fortune in an Eastern temple: and it is not impossible that some of the " ethereal music " associated with elaborate modern spiritualistic séances has its origin in methods of his contriving.

Although his demonstrations in this matter seemed mere trivialities, his purpose was sufficiently serious as a contribution to the science of acoustics. Many refined and original experiments followed, and were made public by Faraday, Wheatstone's invincible shyness rendering it impossible for him verbally to declare his results. He was appointed Professor of Natural Philosophy in King's College, London. The appointment was not exactly a success. The shy, retiring genius was a student, not a teacher, but his appointment had superb, unexpected results. For the purpose of his lectures he insulated a considerable length of copper wire in the cellars of the college, and showed that an electric current might be transmitted through it. This was not new, for Ronalds had performed the same feat with eight miles of wire in a Hampstead garden eighteen years earlier. But Wheatstone not only proved the passage of the current—he calculated the pace at which it travels, a discovery of vast importance. Then, finding that the speed of the current made transmission and reception practically simultaneous, he applied himself to the task of making his wire convey signals. Here again he was not originating, for he owned himself indebted to the mastermind of Francis Ronalds, whose telegraph he had seen years before. But Wheatstone, joined by Fothergill Cooke, carried the invention slowly to perfection, and did for England the like of that which Morse did for America. For a fuller survey of the coming of the telegraph the biographies of Cooke, Morse, and Ronalds should be read.

The first patent was taken out by Wheatstone and Cooke in May, 1837, " for improvements in giving signals and sounding alarums in distant places by means of electric currents transmitted through metallic circuits." In those words did the partners modestly announce to the world their creation of a then unmatched marvel of scientific invention. A host of improvements followed, so that Wheatstone lived to see the telegraph not merely a scientific but also a commercial success. Many other inventions stand to his credit—the stereoscope; the polar clock which tells the hour of the day by the light from the sky, even though the sun be obscured; a typewriter; the rheostat—an electric instrument for regulating a circuit so that any required degree of force may be maintained; electrically synchronised clocks; the telegraph barometer, by which an observer at the foot of a mountain can read the instruments on the summit; methods of converting dynamic into electrical force, and so forth—a prodigious list, each important or interesting enough to have made him famous. In spectroscopic analysis he demonstrated a method of discovering the presence of very minute portions of any given metal. He did not seek immediate practical application of his discoveries. " We have here," he said of the method instanced, " a mode of discriminating metallic bodies more readily than by chemical examination, which may hereafter be employed for useful purposes," a remark cited as typical of his far-sightedness into the practical utility of a known scientific fact.

Wheatstone had a curious hobby—the deciphering of hieroglyphics and ciphers. He and Lyon Playfair devoted their leisure to unravelling the cipher advertisements in the " Times," and followed with interest the communications of an Oxford graduate

who felt so sure of his method that he kept up a public correspondence in this manner with a young lady in London. At last he proposed an elopement! Wheatstone thereupon issued a remonstrance in the "Times" to the lady in the same cipher. There followed a despairing appeal to the young man, "Dear Charlie, write no more; our cipher is discovered!" And the rest was silence. Wheatstone, whose degrees and distinctions from all parts of the world numbered nearly twoscore, died in Paris on October 19, 1875.

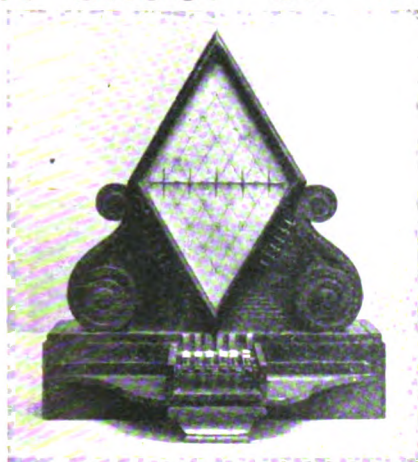
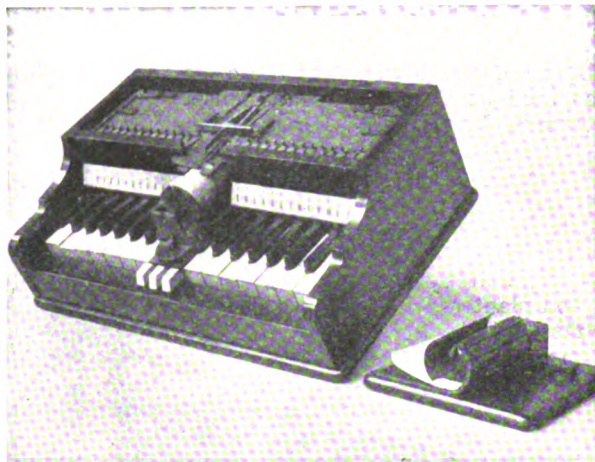
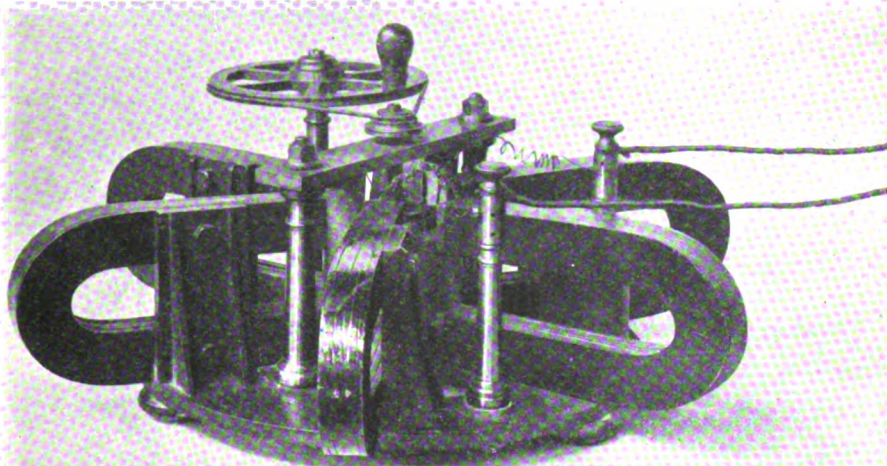
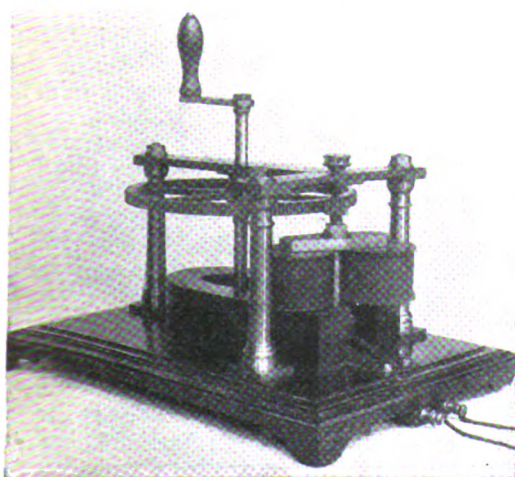
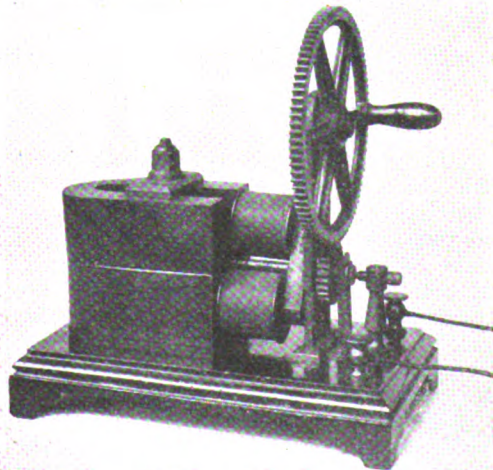
ROBERT WHITEHEAD

Creator of a Monster of the Sea

Robert Whitehead, inventor of the torpedo called by his name, was born at Bolton-le-Moors, Lancashire, on January 3, 1823, and was apprenticed to Messrs. Richard Ormerod & Son, engineers, of Manchester, for whom his uncle was manager. Whitehead seized every opportunity of improving his theoretical knowledge by attending evening classes and lectures, and so laid the foundation of that rare skill in engineering draughtsmanship which remained with him all his life. As a young man, he followed his uncle to Marseilles, whence he travelled to Milan and engaged in business on his own account, inventing improvements in weaving machinery in the silk industry, and patenting a machine for winding silk from the cocoon. Austria ruled in Northern Italy at this time, and at the revolution of 1848, Whitehead's patents, being Austrian, were annulled by the Italians. The latter owed him gratitude, for he had designed, built, and directed the operation of machinery for draining some of the marshes of Lombardy. Had his patents not been revoked, he would have remained in Italy, and the most deadly engine of war would have continued unborn! To Trieste he went, and thence to Fiume, where he built among others the engines of the Austrian man-of-war the "Ferdinand Max," which was flagship at the battle of Lissa.

In 1866 an Austrian naval officer, finding Whitehead a power in naval construction circles, took to him the model of a torpedo which he had invented. It was simply a clockwork boat charged with powder at the bows, which could be exploded by a percussion arrangement on the boat's striking a ship. Whitehead saw the idea was impracticable, but he realised that if a scheme for a real torpedo could be carried out, the weapon would be a terrible one—so terrible, he thought and hoped, as to make war impossible. For two years he laboured in secret, and then produced his first locomotive torpedo. It was at once lost at sea, the only torpedo in the world. Duplicates were fashioned, and the Whitehead torpedo, first accepted in 1868 by the Austrian Navy, was adopted in turn by every Power with a strip of sea-coast. Various improvements and modifications were effected in course of time; and whereas the earliest torpedoes travelled only 600 yards at eight knots, and that erratically, those made at the time of their inventor's death had a speed of thirty-six knots, a maximum range of 4000 yards, and terribly accurate aim.

The invention which was to abolish war has failed in its pacific object; it has grown into a monster of vastly evil potentialities, so that, although Great Britain is second to none in offensive and defensive equipment, military critics frankly tell us that it would have been well for this country had the torpedo never been invented. No other warlike invention has created results so profoundly revolutionary. It has affected naval construction, armaments, and tactics. It has called into existence successively the torpedo-boat, the catcher, the destroyer, and the submarine. In armament it has necessitated the production of the quick-firing gun, with all its developments. On the defensive side it has involved elaborate net defence, the searchlight, the subdivision of the modern warship into a multitude of water-tight compartments. In tactics it has compelled the opening out of action so that operations may be conducted, beyond the range of the torpedo, by guns of enormous power and range. In strategy it has thrown grave doubt upon the power of any Navy to carry out a blockade. In general preparation for war it has necessitated the maintenance of boom defences and the construction of enormous and vastly costly works for the defence of anchorages. These, as has been pointed out by the "Times" military critic, are among the palpable developments resulting from this invention which was to abolish war, an invention still in its infancy! The inventor, who was the recipient of many foreign decorations, established works in England, as well as a huge establishment at Fiume, and during his later years had a charming estate at Paddockhurst, Sussex. He was described as "modest and retiring, but genial; unobtrusively benevolent, full of loving-kindness." He died at Beckett Park, near Shrivenham, on November 14, 1905.

A GROUP OF WHEATSTONE'S INVENTIONS

FIVE-NEEDLE TELEGRAPHIC MACHINE

THE TYPEWRITER MADE ABOUT 1856

MAGNETO-ELECTRIC MACHINE WITH SIX COMPOUND STEEL MAGNETS, PATENTED IN 1858

MAGNETO-ELECTRIC MACHINE OF 1840, IMPROVED FROM AN EARLY MAGNETO-ELECTRIC MACHINE, AND INCLUDED IN THE COLLECTION OF MODELS PRESENTED BY WHEATSTONE TO THE NATION

ELI WHITNEY

An Invention which Riveted the Chains of Slavery

Eli Whitney, inventor of the cotton-gin, was born at Westboro', Massachusetts, on December 8, 1765, and, partly by teaching, partly by manual labour, managed to educate himself at Yale College, where he graduated at twenty-seven. Afterwards he went to Georgia, where he was befriended by the widow of the Revolutionary General Greene, and by her he was introduced to cotton planters who were anxious to secure a mechanical means of separating cotton from its seed. Whitney, who had a genius for mechanical invention, quickly evolved his famous cotton-gin. It was extraordinarily effective for the purpose, and was created by tools of the inventor's own fashioning. Like the Nasmyth hammer it was an invention to order, produced with almost incredible celerity. The success of the machine in effect was that whereas by the old hand method only from five to six pounds of cotton could be cleaned per day by one person, through its use one person could clean 1000 pounds of cotton a day.

Whitney, as was usual with the inventors of his era, had ill luck with his machine. Unscrupulous rivals broke into his premises, stole his model, and spread gins of their own making broadcast. He had long and costly legal battles to establish his patent rights, and the expenses swallowed the profits and grants made him in respect of the contrivance. He therefore established himself at what is now Whitneyville, near New Haven, Connecticut, as a maker of firearms, secured important Government contracts, introduced the system of subdividing labour and the standardisation of parts, and realised a fortune, but not from the machine with which his name will always be associated.

The cotton-gin, one of the most important of all the contrivances connected with cotton manufacture, produced results which none could have foreseen, good in enormously extending supplies of raw material for manufacturers; monstrously evil in a totally unexpected direction. The commercial results may be estimated from the exports of cotton to England. In 1792, the year before the cotton-gin was invented, English imports of American cotton amounted only to 138,000 pounds; in 1795 they totalled upwards of 9,000,000 pounds, and in 1801, eight years from the appearance of the gin, 20,000,000 pounds of cotton. So far, good. But a deplorable thing now happened. Prior to the advent of the cotton-gin American opinion had been doubting the morality, the economy, and the expedience of slave labour. Congress declared that no more slaves should be imported into any of the thirteen States; and Vermont, Pennsylvania, Massachusetts, and other States abolished slavery.

The retention of slaves was not worth while, seeing that a man could clean but five pounds of cotton a day. Cotton was not profitably to be cultivated save in Oriental countries where labour was less costly than the maintenance and supervision of slaves. Slavery was therefore slowly dying a natural death throughout America. But with the appearance of the cotton-gin all was changed so far as the commercial aspect of slavery was concerned. With 1000 pounds of cotton cleaned per day, a slave became a great revenue-producing institution. Cotton planters flocked to the Southern States, and the demand for slaves grew enormously. Slaves from States which could not grow cotton were transferred to those which could, and the cotton planters settled down to hold their slaves "for ever," as they hoped. The terrible Civil War was fought for the right of certain States to secede from the Union. They desired to secede only in order that they might retain their slaves, whose labour the cotton-gin alone had made a source of great profit.

Thus a simple invention—a toothed cylinder, a grid between whose interstices the teeth pass to tear the lint from the seeds, to let the latter fall on one side of the machine and the lint on the other—this toothed wooden cylinder and grid and a revolving brush to remove the débris added incalculable millions to the wealth of the world, and yet kept a people in bondage for nearly seventy years. When the Civil War broke out, of the twelve million inhabitants of the Southern States, every third person was a slave, and the cotton-gin had raised the value of the latter to £350 per able-bodied slave. When the Confederate Army took the field it was to fight for the ownership of black flesh and blood, valued at between £250,000,000 and £800,000,000, a value fixed by the cotton-gin. Whitney died at New Haven on January 8, 1825.

THE MARQUIS OF WORCESTER

Inventor of the First Steam Engine

Edward Somerset, sixth Earl and second Marquis of Worcester, was born, probably in 1601, at Worcester House, in the Strand, and was educated privately at home and

on the Continent. In the wars of the Commonwealth he was secretly commissioned by Charles I. to raise armed forces in Ireland and in Europe for the subjugation of the kingdom, but upon discovery of the scheme was disowned by his faithless master. So he fled to the Continent, was proscribed and suffered confiscation of his estates. Reduced to abject poverty, he risked all and returned to England, and was imprisoned for two years in the Tower. At the Restoration he claimed that he had disbursed over £900,000 in the Royalist cause, and recovered a share of his lost estates. His pronounced Romanism prevented him from gaining Court influence, and he is chiefly interesting to posterity as the author of a puzzling book, his "Century of the Names and Scantlings of Such Inventions as at present I can call to mind to have tried and perfected." The book, written in 1655, and first printed in 1663, has been repeatedly republished, but to this day experts cannot agree as to what relation the matter published bears to the actual inventions.

Some of the entries are condemned, as, for example, that in regard to shorthand, on the score that shorthand had long existed before the Marquis was born. That is no proof that he did not invent a system with the belief that it was the only one extant. Then it is urged that Somerset's details are too vague to be accepted; no one could construct the machines he described from the particulars he gave. If that argument were to pass unquestioned, we should have to apply it to scores of other inventors of proved ability.

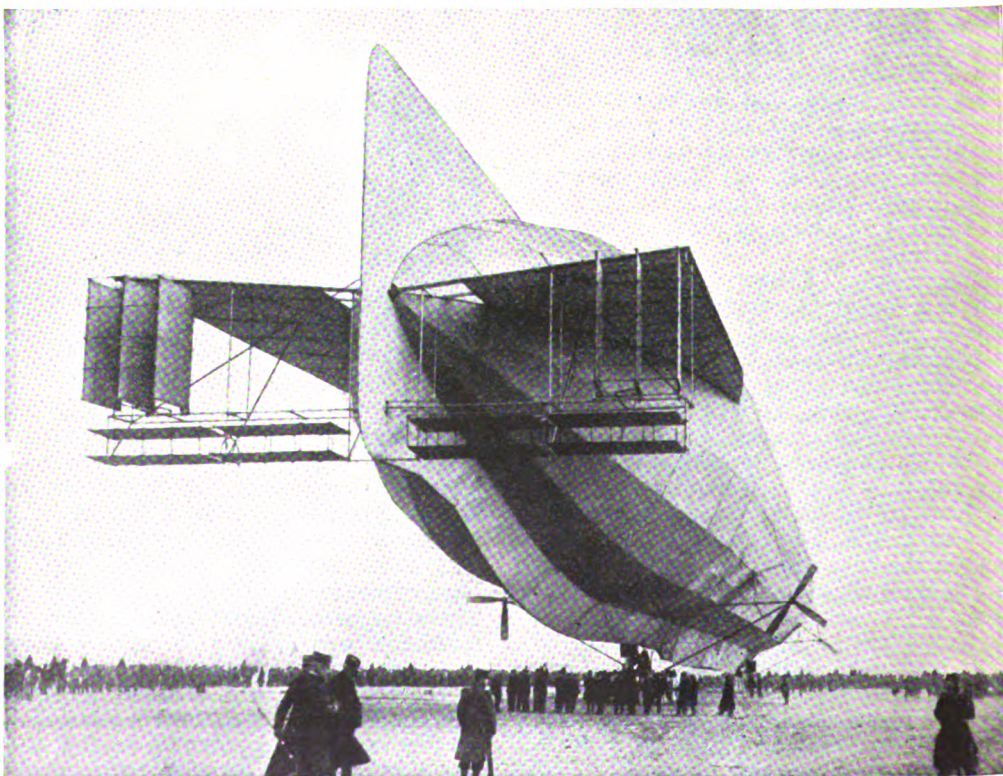
Worcester's "Century of Inventions" covers a variety of ground, such as ciphers, signals, automata, and various mechanical appliances, some of them absurd or impossible, some apparently bombastic pretence. But the sixty-eighth makes its author for ever famous. It describes "an admirable and most forcible way to drive up water by fire." Worcester seems first to have tested his appliance at his home, Raglan Castle, before the war; to have nursed the idea during all the years of his troubles; to have perfected it, theoretically, while a prisoner in the Tower; and finally to have carried it into effect at Vauxhall.

It is passing strange that the historians cannot agree as to whether the inventor really had his steam-engine in existence or not. Robert Hooke, who visited this Vauxhall "college for artisans," spoke of it as "one of the perpetual-motion fallacies," but was not improbably wrong. There did exist in the Marquis's equipment a so-called perpetual-motion machine, and possibly this may have been confounded with the steam-engine. For in 1663 Samuel Sorbière saw and described what he termed the "hydraulic machine which the Marquis of Worcester has invented," and six years later the Duke of Tuscany saw it at work.

Of course, all relics of the first machine have vanished, and investigators have even searched the dead man's tomb for traces of the model. It perished, as other first forms of machinery perished. The Marquis

THE MARQUIS OF WORCESTER

of Worcester worked a steam-engine from which he hoped to make a fortune. As the engine described in his book is a really admirable contrivance, it is surely but logical to assume that the one which raised water to a height of forty feet at Vauxhall was of the same type with the one outlined in his "Century of Inventions." There seems no doubt that this Royalist nobleman was really the father of the first steam-engine made since Hero perplexed his contemporaries in old Alexandria two thousand years ago. The Marquis of Worcester died in London on April 3, 1667, and it is said that his engine continued to work until three years after his death.

THE FIRST MAN TO FLY IN EUROPE. WILBUR WRIGHT ON HIS BIPLANE AT PAU IN 1908

THE ENFORCED DESCENT INTO FRANCE OF THE MONSTER ZEPPELIN AIRSHIP Z4

PIONEERS

VISCOUNT TOWNSHEND—THE STATESMAN ON THE FARM

WILLIAM TUKE—WHO INTRODUCED KINDNESS FOR THE INSANE

MR. AND MRS. SIDNEY WEBB — QUIET REVOLUTIONISTS

JOSIAH WEDGWOOD — THE KING OF ENGLISH POTTERS

WILLIAM WILBERFORCE — THE GREAT EMANCIPATOR

WILBUR AND ORVILLE WRIGHT — THE FIRST MEN TO FLY

ARTHUR YOUNG—PIONEER WRITER ON AGRICULTURE AS A SCIENCE

COUNT FERDINAND ZEPPELIN — THE FATHER OF DIRIGIBLE AIRSHIPS

VISCOUNT TOWNSHEND
The Statesman on the Farm

CHARLES, second Viscount Townshend, was born at Rainham, Norfolk, in 1674, and, with Sir Robert Walpole, his junior by two years, and future rival and successor in office, was educated at Eton and King's College, Cambridge. It is one of the greatest ironies of public life that Townshend, a profound scholar, and one of the most considerable figures in Europe for a number of years, is today of absolutely no account, yet as "Turnip Townshend" he is immortal! Charles II. and the future James I. were his godfathers; he entered the House of Lords as a Tory, became a great Whig, helped to negotiate the Act of Union between England and Scotland, and all the great treaties between the United Kingdom and the various Continental Powers with whom we had relations; was Prime Minister, and had the gift of all the offices of State: helped materially to effect the seating of the House of Hanover on the throne of Britain; made Walpole his Chancellor of the Exchequer, and was in turn ousted from the first place by the younger, more able, and thrustful man. But it all goes for nothing today. He went to Hanover and brought back a turnip, and that now is his claim to fame!

Wearied of public life, he retired, disappointed, at sixty-four, to spend the short remainder of a long career upon his land at Rainham. His public career was not without influence upon his agricultural practice. He was in Hanover, as Secretary of State under George I., when he noticed the enlightened methods of cultivation practised in his sovereign's native land. In particular he noted the prosperity of the farmers who cultivated turnips. He brought back with him turnips and a scheme. English husbandry had reached a crisis. The old method of tillage still survived, in which, of all the land in cultivation, one-third had to lie fallow every year to prevent it from becoming exhausted. Of all the cultivable land in the country, one-third was always idle for this reason. Consequently food was scarce for man and beast, and the reduction of available land necessarily limited the scope of labour. Townshend brought back the Hanoverian system of tillage. He quietly introduced the system with his turnips at Rainham; and without any Act of Parliament, without any international treaty, without advertisement or proclamation, he began a complete revolution of agricultural methods in this country.

As a statesman he was a mere name to the generality of the men and women of his own age; as an agricultural reformer he was a saviour. He established a system of agriculture which for ever associates his name with the turnip, and his native Norfolk with that of the four-course rotation of crops. It was for these improvements that he abandoned the lustre of a Court and the glamour of participation in international policy. Arthur Young, who by his writings first elevated agriculture to a science, is qualified to speak of Townshend, for he himself made 3000 agricultural experiments, all unsuccessful, and brought himself to ruin as a farmer by his plans. He could appreciate the success of others, though he could not himself attain it in practical husbandry.

"The importance of embassies," he wrote, "of vice-royalties and seals, is as transitory as that of personal beauty, and the memory of this lord (Townshend), though a man of great abilities, will in a few ages be lost as a minister and statesman, and preserved only as a farmer." The prediction, written a century ago, has been entirely realised so far as the great bulk of the people of this country are concerned.

Townshend the statesman does not matter, but, as the originator in England of the four-course rotation of crops, Turnip Townshend may yet be canonised by a grateful generation of farmers. What his innovation has meant to the country in hard cash and increased food-supply only a statistician with the scientific use of the imagination can justly estimate. Lord

Townshend died at Rainham on June 21, 1738. As a statesman he is described as choleric, vindictive, and honest; as a farmer, energetic and inventive. From his system developed the possibilities of raising the cattle and sheep which have made England pre-eminent as the source of the world's finest live-stock.

WILLIAM TUKE
Who Introduced Kindness for the Insane

William Tuke was born at York in 1732, of Quaker parents. As a member of the Society of Friends, he was interested in various philanthropic objects, and travelled a good deal in search of further knowledge for the amelioration of human suffering. In the course of his travels he saw something abroad of the methods of Philippe Pinel, the French doctor who was then trying to do something for the insane. For many ages, "Dark," "Middle," and "Modern," the insane had been treated with what Shakespeare tells us is the only darkness—ignorance. They were held to be possessed by the devil, or devils, and horrible cruelty was the accepted method of dealing with them. William Tuke saw enough to convince him that humanity was the best method, even from the purely medical and practical standpoint, for dealing with the insane. He returned to York, and founded in York the world-famous asylum which he and his helpers called the Retreat. This was first proposed by him in 1792.

At the Retreat the patients were treated kindly—not as devils or criminals, but as patients. Chains and unnecessary restraints were abolished. The incessant use of drastic drugs and of bleeding was discouraged—a very bold step in itself; and the great success of the Retreat, under the wise and kind management of William Tuke and his son Henry, ultimately led to reform throughout the country. When all honour is paid to medical pioneers like Pinel and Esquirol in France, and to Conolly at Hanwell, we must acknowledge the Retreat, founded by William Tuke, as the first humane asylum for the insane.

Much legislative interference on behalf of these unfortunate people followed upon the revelations made by William Tuke, and he lived to see his principles and his practice acknowledged and honoured everywhere, even by the medical profession, whose traditional methods he had so signally and successfully flouted. The Retreat remained under his care, and that of his son, until his death, and has been under the care of the Society of Friends since. It is what it always was, but, thanks to itself, has ceased to be remarkable.

William Tuke died in 1822, but he founded a family which forms part of any true biographical record. His son Henry, already named, had a son Samuel (1784-1857), who was a notable writer on the care of the insane; and a second son, the late Dr. Daniel Hack Tuke (1827-1895), who was one of the greatest alienists of his time, edited the "Dictionary of Psychological Medicine," and wrote a book, only now beginning to be appreciated, "The Influence of the Mind Upon the Body."

MR. AND MRS. SIDNEY WEBB
Quiet Revolutionists

Mr. and Mrs. Sidney Webb are linked together here as among the most substantial social workers, on literary lines, in our generation. They have been both recorders and inspirers. Mr. Sidney Webb was born in London on July 13, 1859, and educated in London, Switzerland, and Germany. Before he was twenty he was a junior clerk in the War Office. Presently he became a Surveyor of Taxes, then entered the Colonial Office, where he remained till he took an active part in voluntary administrative public life, in 1891, as a member of the London County Council.

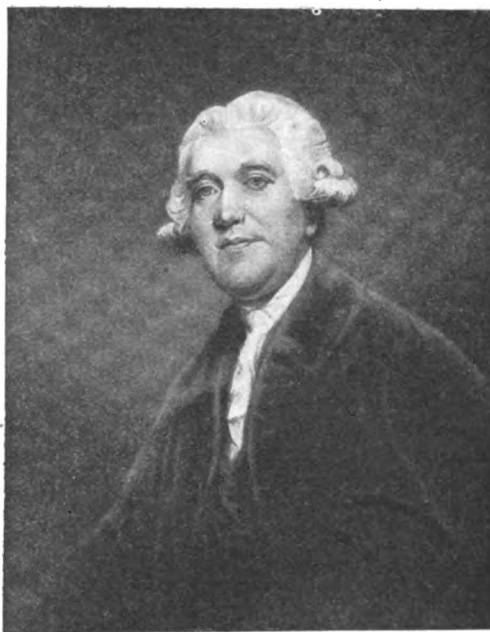
He first became known to the public as one of the most active and able members of the Fabian Society. In 1892 he married Miss Beatrice Potter, a daughter of Mr. Richard Potter, chairman at one time of the Great Western Railway Company, and a sterling friend of Herbert Spencer. Mrs. Webb herself was so dear a friend of the great philosopher that he expressed a wish that she might be present when he died. She was born in 1858. She participated in the work of Charles Booth while he was bringing together the materials for his "Life and Labour of the English People." Before her marriage Miss Potter had acquired a sound knowledge of industrial conditions, and had written the story of the "Co-operative Movement in Great Britain." Mr. Webb founded, in his younger days, the London School of Economics and Political Science, and was himself an honorary lecturer on Political Economy at the City of London College.

Since their marriage both Mr. and Mrs. Webb have done fine service on various Commissions—the husband, who is a barrister, on the Trade Union Law Commission, Departmental Committee on the

Technological Institute of South Kensington, Agricultural Settlements and Emigration, Territorial Army, and Census of Production; while Mrs. Webb was a member of the Royal Commission on the Poor Law (1905-9), and is hon. secretary of the National Committee for the Prevention of Destitution. Before his marriage Mr. Webb had written on "Socialism in England" and "The Eight Hours Day," and since has collaborated with his wife in a fine series of books which tell of social progress or of the historical organisation of English life. Thus the two have written a "History of Trade Unionism," on "Industrial Democracy," "Problems of Modern Industry," a "History of Liquor Licensing," and a series of books on the story of English Local Government, surveying it in all its historical developments from the ancient manor to the modern city. Lastly, the Webbs were responsible for the Minority Report of the Poor Law Commission in 1909, which promises to lead up to the reorganisation of national methods of dealing with the dependent poor, young and old.

Great numbers of people are engaged, more or less loosely, in examining and discussing and trying to influence such movements as are mentioned in the books written by the Webbs—the most intimate sociological and economic questions of the world up to date. But here are two observers who, with great knowledge, literary skill, scientific judgment, and a sane sympathy, are collating the records of these tendencies and present-day phenomena, and are trying to lay solid bases for future developments. The most significant work they have done, with a breadth of outlook that has made it entirely independent of political partisanship, is the preparation of the Minority Report on the Poor Law problem. We are in the midst of a quiet revolution in the treatment of the poor, diseased, and unfortunate, which will end in the abolition of the workhouse as it has been known in the past, and the substitution of far more humane, scientific, and remedial forms of organised help; and the people who, more than any others, have shaped this movement and given it weight, intelligence, and conscience, are Mr. and Mrs. Sidney Webb

JOSIAH WEDGWOOD
The King of English Potters

Josiah Wedgwood was born near Burslem, Staffordshire, and baptised in the parish church there on July 12, 1730. His life is briefly reviewed and his work estimated on pages 983-86 of the present work. Some few supplementary biographic details may here be added. It has been shown how, from an early illness, he suffered from an injury to the right leg, and how, during all the years in which his struggles for success were in progress, the pain and disability of his handicap hindered him at his work. Not until he had borne this injury for twenty-seven years did he screw his courage to the sticking-point and have the maimed limb amputated. The boy left school at nine, but was all his life a student, interesting himself especially in chemistry. Probably he did not, to the end of his days, know as much of his favourite subject as the average seventh-standard boy of today, but he

JOSIAH WEDGWOOD

knew marvellously how to apply such knowledge as he had mastered. He served an apprenticeship to his elder brother Thomas, who was not altogether enamoured of the youngster's passion for experiment and original design and methods, so that, at the completion of his term of service, Josiah was glad to transfer himself to the service of outsiders. Living frugally and studying hard, Wedgwood felt justified, when he was about eight-and-twenty, in setting up a little establishment of his own.

He was now free to experiment as he would. He yearned to better the processes which he had been compelled in the main to follow. In order to do so he had to revolutionise workshop practice, to insist upon

cleanliness and order, to demand exactness of work, to teach his men to be artistic potters instead of mere thumpers of wet clay. It was a great triumph for him when he was able to produce wares in which lids fitted, spouts poured, and handles could be held. But he was striving for a better type of ware than any yet known to England, and the story of his efforts reads like a modification of that of Bernard Palissy. In essaying the improvement of the ordinary cream-coloured ware, he considered with minute attention every detail of the body, glaze, form, and ornament. There have been few happy accidents in the history of pottery, and Wedgwood found himself baffled again and again. The ordinary goods that he sold were so much better than those of his neighbours that he could have made a very comfortable living without further improvement, but the artist was stronger in him than the instinct of commerce. He worried on through trial after trial, doggedly persevering in face of every failure. One kiln after another was pulled down, his biographer tells us, in order to correct some defect or effect some necessary improvement. His losses from this source alone were at this time very heavy, and the ware itself was frequently destroyed before he could bring his firing processes to the right temperature necessary to secure the adequate result. His chemical combinations often completely puzzled him, and his experiments, both in body and in glaze, would, after the greatest care had been expended in their preparation, turn out utter failures. He had to invent, or, failing that, to improve, every tool, instrument, and apparatus, and to seek for smiths and mechanics to work under his guidance. He often passed the whole day at the bench beside his men, and in many cases instructed them individually.

Unwearied and indomitable in spirit, he persevered, and success came, complete and abundant. The famous cream ware, lighter, brighter, and more beautiful than any pottery ever before made in England, was his, and the artist, without sacrificing one whit of his love for his art, became a factor, and a phenomenally successful factor. There was a ready market for his products on the Continent and in America, as well as in England. The success of the Wedgwood ware was helped by his appointment as Royal Potter to Queen Caroline, through whose patronage it became known as "Queen's ware." The inventor had a shrewd suspicion that its phenomenal success was not wholly due to its intrinsic merit, for he wrote of it to Thomas Bentley, whom he had taken into partnership: "It is really amazing how rapidly the use has spread almost over the whole globe, and how universally it is liked. How much of this general use and estimation is owing to the mode of its introduction, and how much to its real utility and beauty, are questions in which we may be a good deal interested for the government of our future conduct; for, if a royal or noble introduction be as necessary as beauty to the sale of an article of luxury, then the manufacturer, if he consults his own interests, will bestow as much pains in gaining the favour of these advantages as he would in bestowing the latter."

As against this exposition of worldly wisdom, let us glance at the more ideal aspirations animating Wedgwood in the pursuit of his calling. He writes, also to Bentley, in proposing the partnership to him: "If you think you could really fall in love with and make a mistress of this new business, as I have done, I should have little or no doubt of your success; for, if we consider the great variety of colours in our raw materials, the infinite ductility of clay, and that we have universal beauty to copy, we have certainly the fairest prospect of enlarging this branch of manufacture to our wishes; and, as genius will not be wanting, I am firmly persuaded that our profits will be in proportion to our application. I am as confident that it would be, beyond comparison, more congenial and delightful to every particle of matter, sense, and spirit in your composition to be the creator, as it were, of beauty rather than merely the vehicle or medium to convey it from one hand to another."

It is unnecessary to follow Wedgwood through all the details of the career which now opened out to him; these belong of right to the history of ceramics, and may be consulted in earlier portions of the present work. It is but just to say that he embellished and, indeed, revolutionised every branch of pottery and earthenware manufacture in which he engaged. He took a large share in the industrial development of Staffordshire. His own works at Etruria became a centre of industry from which the fame of English pottery was carried to all parts of the civilised globe. When the Empress of Russia ordered two dinner-services from the Wedgwood establishment, paying some fifty guineas for the actual ware and forty times as much for its decoration, the staple trade of Staffordshire

became universally celebrated. Wedgwood's prosperity enabled him to speak with a voice of authority upon such matters as the internal communications of his native county; and the building of the Grand Junction Canal, uniting the Mersey, the Trent, and the Severn, was largely brought about by his sage counsel, while he himself was able, at thirty-five, to give £500 for the making of roads, as well as to make a generous contribution towards the founding of a second free school for Burslem.

Wedgwood died at his home, Etruria Hall, on January 3, 1795, leaving a fortune of half a million, fairly earned, as his epitaph records, by means which " converted a rude and inconsiderable manufactury into an elegant art and an important part of national commerce." Married when thirty-four, he became the father of three sons and four daughters. The eldest daughter became the mother of Charles Darwin. " If such speculations are permissible," says Sir Francis Darwin in his biography of his illustrious father, " we may hazard the guess that Charles Darwin inherited his sweetness of disposition from the Wedgwood side." It was another Wedgwood—Emma, granddaughter of Josiah—who became the great naturalist's wife. Her father, the younger Josiah Wedgwood, was indirectly responsible for " The Origin of Species." Darwin's father regarded this second Josiah as " one of the most sensible men in the world," and, after he had refused Darwin's application to make the " Beagle " voyage, relented when Josiah declared that the youth should make the trip. " The voyage of the 'Beagle' has been by far the most important event in my life, and has determined my whole career," the naturalist afterwards wrote. So we must think with kindness of the wise, strong man whose word made the voyage and its immense results a possibility.

WILLIAM WILBERFORCE
The Great Emancipator

William Wilberforce was born at Hull on August 24, 1759, the son of a wealthy old Yorkshire house, and after a career at Cambridge, in a " port and prejudice " atmosphere, where tutors and Fellows did their best to make him a lazy, conceited prig, was plunged, by family influence, into a life of idle gaiety. " If Billy turns Methodist he shall not have a sixpence of mine," his grandfather had said, when noticing a serious trend in the young man's disposition. " Billy " did not turn Methodist exactly, but as member for Hull, and afterwards for the county of Yorkshire, he found leisure to travel with the very man whom his grandfather had singled out for the purpose. This was Isaac Milner, who had been one of his early tutors. With Milner, Wilberforce, who from early boyhood had been without a father's care, made a close study of religion, and at twenty-five he had definitely chosen his course in life ; he began a crusade for morality and for mercy and justice to his generation. It cannot be said that it was at this time that he first turned his thoughts to the horrors of slavery, for when only fourteen years of age he had written a letter on the subject to a York paper.

The iniquity and barbarity of the system were troubling the minds of many men. Details of the steps leading to the campaign against this blot on the fame of white men will be found in the life of William Clarkson. Even a cotton planter of the Southern States of America would hardly defend slavery today, but a marvellous change has been wrought in public opinion within the last century and a quarter.

When Wilberforce was born, slavery was sanctioned by use and wont here in free England. Not until the emancipator was thirteen years of age was it determined that slavery could not exist in Great Britain. It is one of the few cases where judge-made law has been satisfactorily substituted for Parliamentary enactment. Legally, the decision was bad; morally, it was superb. The decision was nobly defined in an immortal sentence of Curran's : " The spirit of the British law is that liberty is inseparable from British soil ; that no matter in what language the man's doom may have been pronounced, no matter what complexion, incompatible with freedom, an African or an Indian sun may have burnt upon him, no matter in what disastrous battle his liberties may have been cloven down, no matter with what solemnities he may have been devoted upon the altar of slavery, the first moment he touches the sacred soil of Britain, the altar and the god sink together in the dust." The decision merely gave judicial sanction to the desires of the highest public opinion ; it did not really express the existing law.

For slavery *was* sanctioned in England ; it was a part of our national system. The land had never been wholly free from it. After the Conquest the distinct slave-class ceased as such to exist, and was merged with the lower order of ceorls into the general body of villeins. And slavery had

never been abolished by Act of Parliament in this realm. The decision in question was therefore the noblest example of bad law that our courts have ever given us. But it left untouched, of course, the scandal of the slave trade. That was officially recognised. From the time of Queen Elizabeth forward it had been a lucrative employment for the men who went down to the sea in ships. The great "advantage" conferred upon this country by the Treaty of Utrecht was the bestowal upon England of the exclusive right to supply slaves to the Spanish and Portuguese possessions.

When Wilberforce came out upon the question he was flying in the face of his sovereign. The wretched George III. had caused a letter to be written to the Governor of Virginia directing that that official should not, "upon pain of the highest displeasure," assent to any law by which the importation of slaves should be in the least altered or limited. The fatuous old king had the selfish support of all the "interests." All our mercantile houses were more or less implicated in the traffic, and our noble families profited directly or indirectly from it. They or their kin had plantations in the West depending for their prosperity upon the miserable labour of their human beasts of burden.

The history of a preceding age makes curious reading—Gladstone defending the slave trade; Shaftesbury passionately opposing every human right that the Reform Bill proposed; Peel and Bright exerting their influence and oratory to the end that the factory-owner and the mine-owner might maintain their sacred right to treat their employees a little worse than the meanest of their cattle; Sir Joseph Banks ridiculing the steamship; Palmerston forbidding the building of the Suez Canal; savants of the Royal Society sneering wireless telegraphy back into its cradle. We do well, at times, to question the judgment of our leaders. Wilberforce did not question it; he fought it with all his strength, and, after a life-long fight, beat his betters.

The memorial of the campaign's beginning is recorded in a sylvan retreat in Kent. Upon a stone seat that invites the passer-by to repose beneath an ancient oak in Holwood Park—within rifle-shot of Darwin's old home and Lord Avebury's—upon this seat are carved the following words: "I well remember, after a conversation with Mr. Pitt, in the open air, on the root of an old tree at Holwood, just above the steep descent into the Vale of Keston, I resolved to give notice, on a fit occasion, to bring forth the abolition of the slave trade." The words are extracted from the diary of Wilberforce, and mark the opening of his long crusade.

He began by agitating, not for the abolition of slavery, but for much less. Through ill-health he had to get Pitt to move a resolution for him pledging the House to inquire into the whole question of the traffic. The next step was to lead a number of public men down to the Thames to inspect a slave-trading ship fitting out, and these, having seen the mere vessel, induced the Commons to pass a Bill limiting the number of slaves a ship might carry. Even that slight concession was bitterly opposed by the vested interests, but it was a valuable gain, for it marked the first step towards the great goal sought. It established a principle.

Reform was opposed at every stage on the most insincere and callous pleas. At first its opponents said that if England abandoned the traffic, then France would monopolise it, and attain commercial pre-eminence. When the French Republic denounced the traffic, Anti-Abolitionists held up their hands in horror: "What! Adopt a scheme which would associate this country with the infamous ruffians of the French Revolution!" they said. As the battle progressed, conditions for a time grew worse, instead of better. England was gaining new colonial territories in her wars, and African slaves were much in demand. The first material advance was gained in 1805, however, when, by an Order in Council, the traffic with newly acquired colonies was prohibited. This was followed in the next year by an Act making it unlawful for a British subject to trade anywhere in slaves, except as regards the original British colonies. In 1807 the traffic was totally abolished, and successive Acts made the crime punishable, first by fine, then by imprisonment, next by death, and finally by transportation. Nineteen years' labour had gone to the securing of this reform, and what did all the gains mean? Simply that Britons were no longer allowed to capture or acquire their fellow-creatures and sell them as slaves. The actual slavery itself was left untouched.

The work had broken the health of Wilberforce, and had brought him nearly to the end of the great fortune with which he had begun. One of his elections, fought against the Fitzwilliam and Harewood interests, cost Wilberforce £30,000, and his

supporters a further £70,000, while the unsuccessful candidate, Lord Milton, a slave-owner, spent £500,000. But having gone so far with their object, Wilberforce and his friends thrust forward with the question of the abolition of slavery itself, and in sixteen years they achieved this reform—that a Government circular was issued to the West Indian settlers to the effect that they should no longer flog women, and that the use of the whip in the fields must be discontinued.

Our patriots at once threatened to cut themselves out of the Empire and make themselves independent! In Demerara an English missionary, who had sought merely to civilise the slaves, was tried by court-martial and allowed to die in prison. The planters complained that for him to "address a promiscuous audience of black or coloured people as 'my brethren and sisters' is what can nowhere be heard outside Providence Chapel!" John Smith's martyrdom probably did as much for the emancipation of the British slave as John Brown's did for the American. Wilberforce laboured till the end for the work to which he had given his life. He was absolutely absorbed in it, so that even his own children did not know him, and fled at his approach. "They are frightened of strangers," their nurse told him. During the last twelve years of his life he sat for a smaller constituency than that to which he had been accustomed, and before his death he gained the crown he deserved. It was the announcement that an Act had been passed emancipating the slaves throughout the British dominions.

Wilberforce's energies were directed into many other beneficent channels, but the one work with which his name will ever be associated is the striking of the shackles from a nation's bondsmen. He died in London on July 29, 1833, and was buried seven days later in Westminster Abbey. "Few men," said Brougham, "have ever either reached a higher and more enviable plane in the esteem of their fellow-creatures, or have better deserved the place, than Wilberforce, whose genius was elevated by his virtues and exalted by his piety." But the noblest epitaph and monument of all is the fact that nowhere to-day in this broad Empire of ours, with its thirteen million square miles of territory, and its 435 million people of every race and language under the sun, is there a living soul who is not in literal truth as free as the King-Emperor who gives them unity by ruling over all.

WILBUR AND ORVILLE WRIGHT
The First Men to Fly

Wilbur and Orville Wright, of whom the latter survives, must be considered jointly, for each so sympathetically complemented the work of the other that the results cannot be judged apart. Wilbur Wright was the son of Milton Wright, and was born at Millville, Indiana, on April 16, 1867, his brother Orville being the younger. The father of the Wrights was an itinerant preacher, who became a "bishop" of the religious organisation known as the United Brethren in Christ. The two boys were educated in the schools of Richmond, Ind., and Dayton, Ohio, where their parents eventually settled. They inherited the fine,

WILLIAM WILBERFORCE

simple character of their father, and it used to be said of Wilbur Wright: "There is no telling what extraordinary thing he will do next; the only thing you can count on is the absolute truth of anything he may say—though generally he prefers to say nothing." The Wrights had no scientific training, no workshop experience, save that acquired in their own premises. They began their career in partnership as jobbing printers, and from that drifted into business, in quite the smallest way, as bicycle-repairers.

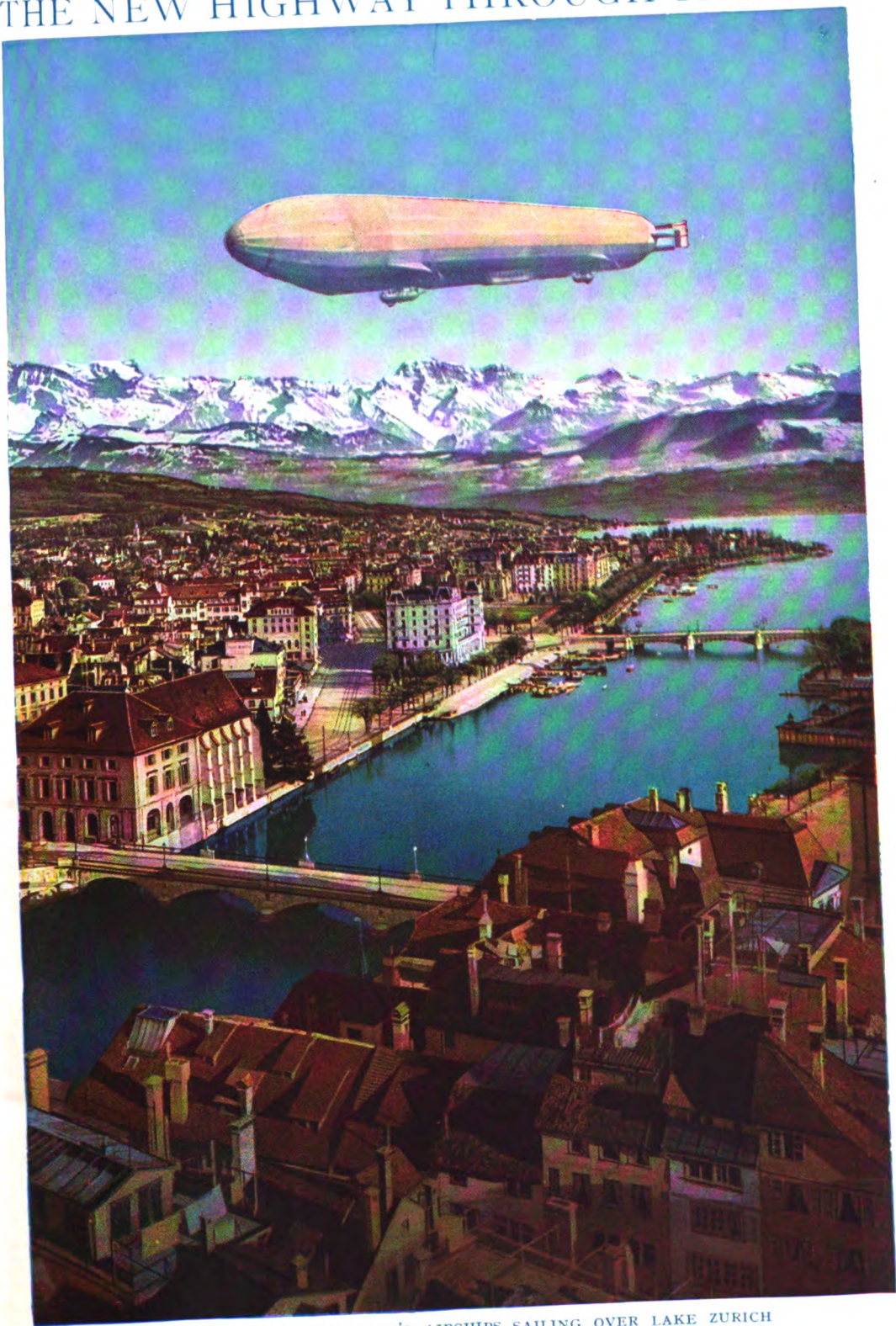
No one would have dreamed that a revolution in locomotion was to have their modest workshop as a cradle. Towards the end of the nineteenth century they began to experiment with problems as to artificial

flight. With Teutonic thoroughness they mastered all the knowledge that was to be gained by reading of what had been done in the same field by others, and with characteristic American initiative they applied their knowledge, supplemented by entirely new ideas of their own, to the production of an aircraft unlike anything that had previously been produced. Other men were experimenting in the same field, but more with a view to dirigible airships. The Wrights aimed at a heavier-than-air machine, to be driven by the new, light, motor-engines. The idea of the heavier-than-air machine itself was not a novelty, for Sir Hiram Maxim had already sought the same end with an aeroplane fitted with a mighty steam-engine. The Wrights were the first to adapt the internal-combustion engine to the purpose; to drive by such an engine a light skeletonised structure, supported by wings fashioned on the plan of the pinions of a bird.

Reference to the chapter on aerial flight, beginning on page 1319 of the present work, will reveal the steps by which aeronauts had been led to acceptance of this principle. But the Wrights did not step into a machine modelled without difficulty upon plans perfected by their dead predecessors. All was difficult and doubtful. The present writer remembers how M. Santos-Dumont, after his successful journey by dirigible round the Eiffel Tower, genially ridiculed the notion of flight to be achieved by a machine modelled on the structure of a bird's wings. "Would you believe it?" he laughed; "I have a friend who is actually studying the wings of all the birds he can get hold of, in the belief that he will be able to introduce the idea of a bird's wing into a heavier-than-air machine!" But although neither M. Santos-Dumont nor the writer with whom he was chatting knew it, these two young American bicycle mechanics were at that very time attempting the supposedly impossible thing. They worked at their plan with extraordinary patience and zeal—and good fortune. Month after month they experimented with various forms of gliding machines, which were little better than glorified box-kites. Funds ran low, but, with the spirit of Palissy, they sacrificed all they dared to continue their work. Their father, a staunch comrade, helped to the best of his ability; their generous-hearted sister succoured them from time to time out of her scanty savings as a teacher.

At last they had learned all that was to be known from the gliding machine. They mastered the secret of balancing by devising adjustable wings on lines already explained at the page mentioned. Ultimately they risked the great adventure; they yoked to their glider a little motor-engine made by themselves, and on December 17, 1903, flew for fifty-nine seconds! In the following year the aeroplane made a hundred short flights, and in 1905 they on six occasions accomplished air-trips of over ten miles, and twice exceeded twenty miles at a stretch. As far as possible they kept their trials secret. They flew out in the wilds on the coast of North Carolina, and for long nobody outside the Wright family knew anything of what was toward. Then the story began to leak out that two mad bicycle-menders were flying in America. Yellow Press reporters got hold of the matter, and cabled over such sensational reports that people in Europe came to the conclusion that the American bicycle mechanics had never flown at all, nor ever would. When Wilbur Wright set out for Europe, in July 1908, with one of his machines, there was considerable scepticism as to his abilities to rise aloft. He established himself in a little shed in a field, first at Autours, near Le Mans, and later at Pau, and prepared to prove their case. The Editor of "Popular Science," who was present at the flights, wrote as follows of the preliminaries and the eventual triumph:

"All day long the crowds gathered about the huge wooden sheds with the great doors. From morning till night they waited in the fields; and as the days went by and nothing happened, the peasants began to scoff and jeer. And then one day the doors of the wooden house swung open, and out came Wilbur Wright, out came Orville Wright, and out came an ungainly machine which is very familiar now, but was something to laugh at then—a huge thing of wood and canvas, of wires and bars and levers, running along the ground on wheels. And the peasants laughed more than ever. This, then, was the thing they had waited weeks to see. As the machine was run into the middle of the field the peasants jeered more than ever. But Wilbur Wright cared nothing at all. He sat down in his seat and made ready. 'One!' he shouted. 'One!' jeered the crowd. 'Two!' he shouted. 'Two!' jeered the crowd. 'Three!' he shouted, and the crowd jeered no more, for Wilbur Wright was flying. He came down from the clouds never to be jeered at again, for these people, belonging to the most emotional race in the world, fell on his neck and kissed him. They had seen a new chapter

THE NEW HIGHWAY THROUGH THE AIR

ONE OF COUNT ZEPPELIN'S AIRSHIPS SAILING OVER LAKE ZURICH

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open in the history of mankind; they had seen the first man fly."

The subsequent progress of the Wrights —mainly constructional—is part of the history of aerial navigation. Wilbur Wright died in his bed, a remarkable circumstance considering the risks he ran and the terrible mortality among the devotees of the science of which he and his brother were the pioneers. He died at his home, Dayton, Ohio, from the effects of typhoid fever, on May 30, 1912.

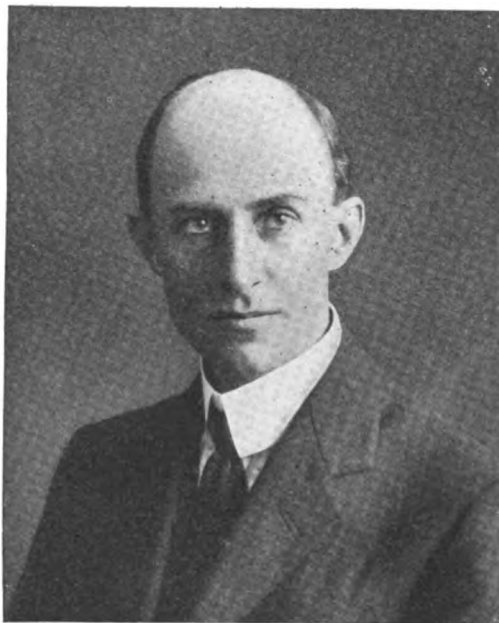
His brother Orville remains to carry on the work alone, and has announced a discovery by means of which he hopes to be able to confer stability upon the aeroplane. Considering how unfortunate have been the pioneers in most new sciences and callings, it is almost surprising to find that Wilbur Wright had £90,000 to leave at his death. But practically all his earnings were saved, for he was one of the simplest-hearted men that ever lived, modest, unassuming, humble-minded as a schoolboy. His kindly nature reveals itself in one charming phrase in his will, bequeathing a sum of money to his father for such little luxuries as Wilbur, had he lived, would have wished him to enjoy The sweet and noble disposition of a George Stephenson lived again in the first man who flew by aeroplane.

ARTHUR YOUNG
Pioneer Writer on Agriculture as a Science

Arthur Young, the farmer-author whose works powerfully promoted the study of agriculture as a science, was born in London, at Whitehall, on September 11, 1741. He was the son of Dr. Young, a prebendary of Canterbury and Chaplain to the Speaker of the House of Commons. He was educated at Lavenham Grammar School, and afterwards apprenticed to a merchant at Lynn. On the death of Dr. Young, in 1759, Arthur left that "most detestable situation" to superintend the affairs of his mother's purely agricultural estate.

He had already shown a passion for scribbling, having written a pamphlet "On the War in North America" when he was seventeen; and for it the publisher gave him ten pounds' worth of books in lieu of money payment. Overflowing with energy, Young began farming on his own account at the age of twenty-two. Though he did not succeed, he persevered, year by year, in testing his theories, acquired a sound knowledge of his business, and in 1770 published "A Course of Experimental Agriculture." During the same period he was gathering facts relating to his subject while touring the counties of England.

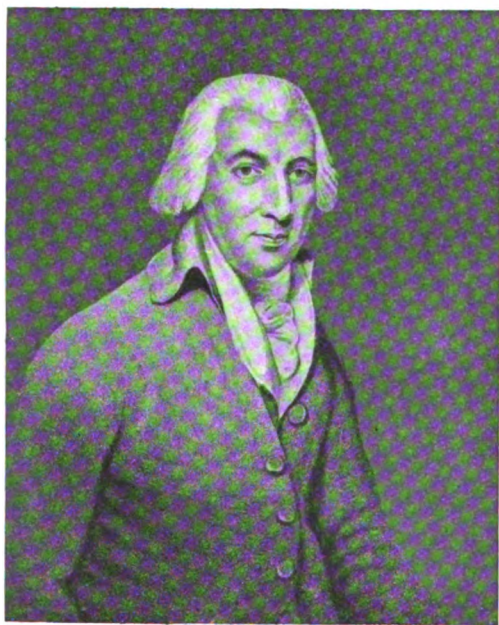
Young's brain was teeming with agricultural ideas. Diarist and annalist, he was as ready with a date and a comment as the immortal Pepys. Contemporary of John Wesley, he was as comfortable in the saddle, as tireless in his journeyings, and as sagacious in his observations as the great preacher. He rediscovered England in the interests of agriculture; and the soil of France and of Ireland was as familiar to him as that of his native land. His pen was more profitable than his plough.

His experiments on his farms were failures,

WILBUR WRIGHT
Portrait by Russell & Sons

but his writings brought him in thousands of pounds. Of epigrams he is a master: "I know not what epithet to give this soil; sterility falls short of the idea: a hungry, vitriolic gravel. I occupied for nine years the jaws of a wolf. A nabob's fortune would sink in the attempt to raise good arable crops in such a country." And sandwiched between solid information and valuable suggestions concerning land, landlords, and labourers are trifles of gossip and vivid descriptions of scenery, all so alluringly compounded that it is no wonder the reading of his books should popularise farming amongst the upper classes.

In a single year he published four important works, one of them, the "Farmer's

Calendar," had reached its 215th edition fifty years ago. The French were so delighted with his services to their country that the Directory ordered his books to be translated and published in twenty volumes, under the title of "Le Cultivateur Anglais," while English scientists made him a Fellow of the Royal Society.

"To the works of Arthur Young," said the chemical philosopher Kirwan, "the world is more indebted for the diffusion of agricultural knowledge than to any writer who has yet appeared." And a more recent writer affirms that "the Farmer's Letters" and "Calendar," as well as the "Tours," went far towards laying the foundation of an agricultural literature.

ARTHUR YOUNG

His "Tour in Ireland" is singularly useful in supplying data by which comparisons may be made between the conditions then prevailing and these of today. Commerce, prices, character of soils and climate, treatment of the poor, absentee landlords, all come under review, while his incidental description of Killarney has found a permanent place in literature.

His account of his French tour was published in two volumes, in 1794, and was entitled "Travels During the Years 1787-90; Undertaken more Particularly with a View of Ascertaining the Cultivation, Wealth, Resources, and National Prosperity of the Kingdom of France." Young speaks disparagingly of French agriculture as then practised, and he does not spare the aristocracy for neglecting their estates and wasting their days at Court. He witnessed some of the earlier manifestations of revolutionary violence.

Young is often claimed by the advocates of peasant proprietorships as a supporter of their views, but John Stuart Mill, who calls him the apostle of the grande culture, points out that Young only favoured such properties "when they are not *too* small; so small, namely, as not fully to occupy the time and attention of the family . . . He recommends accordingly that a limit of subdivision should be fixed by law." Mill, in another passage, describes him as "The inveterate enemy of small farms." Still, it must be added that Young fully appreciates the moral spur that ownership gives to better cultivation and incessant labour. His sayings on this subject have become proverbial: "The magic of property turns sand into gold;" "Give a man secure possession of a bleak rock, and he will turn it into a garden; give him a nine-year lease, and he will convert it into a desert." Yet nothing is so hateful to him as the French métayer system of farming, which he condemns as "the most miserable of all the modes of letting land," as to which many economists entirely disagree.

In 1784 Young began to edit the "Annals of Agriculture." The articles were signed, and this enterprising journalist secured a contribution from George III. (Farmer George), who, however, was permitted to write above the pseudonym of "Ralph Robinson, of Windsor." In 1793, on returning from France, Young was appointed Secretary to the Board of Agriculture, with a house and £400 a year; and he was largely responsible for many official agricultural surveys of English counties. He had married a sister of Fanny Burney's stepmother in 1765. In 1808 cataract affected his sight, and he eventually became quite blind. He died in London, April 20, 1820.

COUNT FERDINAND ZEPPELIN

The Father of Dirigible Airships

Count Ferdinand Zeppelin was born at Manzell, near Friedrichshafen, Lake Constance, on July 8, 1838, and, after a military training in Germany, found his way to America, where he fought in the great Civil War, and gained his first experience of aeronautics in a bad cause, making observations for the Confederates from a captive balloon. He returned to the

Fatherland in time for the triumph of Prussia over France, and was regarded as a highly efficient and courageous leader of cavalry. He was one of the first two Prussians to cross into France, and he fought with great gallantry and distinction, attaining the rank of general. But it is as the inventor of an entirely new military method that he comes into the present section of this work. When his active fighting days were done he turned his attention to the problems of aerial flight

The world still possessed balloons, as it had since the first balloon was sent aloft by the Montgolfiers, but there was still nothing better available. The balloon was, and is, as much at the mercy of currents of the air which carries it as a cork is subject to the swing of the tide that bears it. Zeppelin asked himself if it were not possible to design a vessel new in shape, and new, too, in that it should be rigid, and that it should be capable of being steered against the wind. The problem was like that which beset the old navigators of the waters when they sought to drive a ship against the wind, but with this important difference—that a ship, if it would not advance against wind and tide, did not crumple up; the balloon would.

Zeppelin was past his prime when he first conceived the notion of his rigid airship; he had turned fifty, an age at which men seldom embark upon the work of their life. Yet it was then that he began his serious investigations and experiments. He had to get absolutely away from the old design of a pear-shaped bag of gas with a basket attached. He had to evolve a cigar-shaped or fish-shaped craft on lines similar in respect of outline to that first employed by Fulton for his submarine. That was the first step towards dirigibility and rigidity. The next step was to find the power by which to drive the ship. There was Fulton's submarine for the shape; there was Otto Daimler's internal-combustion petrol-engine for the motive power. The first was decided upon as the result of exhaustive experiment; the second was the obvious implement of the man who could think.

We do well to accord unstinted praise to our Wrights and Zeppelins for their courage and clear-sighted vision, but we must always remember that neither Wrights nor Zeppelins could have been heard of in the world had not that admirable German mechanic Daimler invented the laughable little engine which, mounted on a tricycle, first snorted along the roads of Stuttgart, a generation ago. Zeppelin was fortunately situated, in that the Daimler works were established at Stuttgart, where he had begun his education, and so was familiar, from old associations and from repeated visits, with all that was happening. But Otto Daimler could not build him an airship. That had to be worried out, detail by detail, in his own little workshop. The great thing was that here was the motive power ready to his hand if he could adapt it. The outer world

COUNT ZEPPELIN

knew nothing of his plans until his first primitive models began to take the air. He endured a bitter novitiate. That he, a layman, a mere veteran cavalry leader, should attempt the solution of the problem seemed to the German experts an inexcusable presumption and absurdity; they mocked him, as a host of other inventors of earlier ages had been mocked.

But, with nothing achieved, he declared his plans. "I intend," he said, "to build a vessel which will be able to travel to places that cannot be approached—or only with

great difficulty—by other means of transport, to undiscovered coasts or interiors, in a straight line across land and water where ships are to be sought for; from one fleet station or army to another, carrying persons and despatches; for observations of the movements of hostile fleets or armies, not for active participation in actual warfare. My balloon must be able to travel several days without renewing provisions, fuel, or gas. I must travel quickly enough to reach a certain goal in a given number of days, and must possess sufficient rigidity and non-inflammability to ascend, travel, and descend under ordinary conditions."

With the residue of his savings, and his small pension from the army, and the sale of his family estates—for he put to his work everything he possessed—he scraped together £30,000 for his experiments. His first real airship was completed in two years, and the initial ascent was made over Lake Constance, on October 17, 1900. A second trial brought the machine utterly to grief and collapse. He set to work at once on a second. "Work; do not despair," he said to his helpers, but he himself reached the end of his resources before the second ship was finished. In April, 1903, it was announced that he had come to the end of his financial tether, that his works and plants must be sold, and the work abandoned. A few private friends came to his assistance, Zeppelin II. was finished, and on October 9 of the same year circled and manœuvred all over Lake Constance, and sailed over half a dozen towns away to the mouth of the Rhine. As one Zeppelin airship differs little in essentials from another, a description of this vessel may serve for all. The particulars, given at the time of the successful flight, may here be reproduced, for they indicate the basic lines upon which the construction of all motor airships mainly proceeds. Dimensions differ, of course, and modifications have been introduced to meet discovered defects, but the following outline serves in general as a working idea for all.

The Zeppelin airship takes the form of a cylinder having conical extremities, with a total length of 413 feet and a diameter of about one-tenth of its length. The framework is constructed of aluminium hoops and ribs, over which silk is stretched. Firmly attached to the framework by suspended bearings, and braced up to the aluminium skeleton, are two cars, likewise constructed of aluminium. To increase the stability of the body of the airship, two floats, or aeroplanes, are attached, one at either end. The vessel is driven by two pairs of propellers, actuated by two Daimler motors, one in each car. These motors work the screw propellers, which are fixed in pairs on either side of the airship above the car. It may here be stated that this possibility of employing two cars and two distinct motors is an undoubted advantage of the cylindrical pattern adopted for the main outlines of the airship. This fact was demonstrated on the occasion of the very first trial voyage, for more than once during the trip the rear motor ceased to work, which threw out of gear the pair of propellers driven by it. In spite of this, however, with only the front motor in operation, the vessel continued its progress steadily without interruption. Between the cars and the ends of the airship are the rudders, constructed of aluminium, which are designed to move on fixed axes. Special rudders are provided for steering right and left, and others for moving upwards or downwards. Between the two cars a gangway has been provided, which also contains a shifting weight so adjusted that by its motion backwards and forwards the centre of gravity of the airship can be altered at will. In spite of the failure of the rear motor, the airship maintained an average speed of nearly thirty miles an hour.

The disasters which have attended various airships that have subsequently been built by the indomitable Count are a matter of common knowledge. Craft have collapsed, they have been battered through accident in their sheds, they have been dashed to pieces in trees into which contrary winds have flung them, and one was exploded while moored in the track of a thunderstorm. Through all his misfortunes Count Zeppelin bore himself with the fortitude of a truly great man. A national testimonial placed £150,000 at his disposal following one of his mishaps, and the German Government, after long hanging back, twice went to his rescue from other misfortunes. He merited the help received, for even in his blackest hours of misfortune he scorned the thought of appealing for help from foreign Governments. The German Emperor may have unduly praised the value of the Count-inventor's discoveries, but he carried all the world with him in his tribute to the genius, devotion, and courage of the veteran pioneer.

It is too soon to prophesy as to the ultimate comparative success of the dirigible and other forms of aerial vehicle, but, whatever may be the success attained, Count Zeppelin will be the man to whom the credit of origination will be assigned.

A THOUSAND SCIENTIFIC BOOKS

Of the making of books there is, indeed, no end, and the rapid growth of scientific knowledge in our time has brought into existence an ever-increasing library of its own. The bibliography is an inevitable consequence of this growth of books, and the Editor of Popular Science submits this supplement to the work in the hope that it may prove helpful to students of all branches of science. It does not pretend to be complete; it is not claimed that the books in this list are the best of their kind. Those who use this list, however, will find no book in it that has not a value of its own. These thousand volumes, representing every branch of science, would be a splendid equipment for any library, and the student who has them available has the modern knowledge of life and the world at his fingers' ends.

The books have been chosen from no special point of view, and the chief condition laid down in the preparation of the list has been that every book shall be useful and easily available. Care has been taken to include cheap books, or books not likely to be prohibitive on account of price, but there are necessary exceptions to this rule in any collection of scientific works. A special feature is the large proportion of cheap and popular little books which will be welcome to the ordinary reader. As Popular Science is essentially a book for the home, it has been thought wise to include certain textbooks and schoolbooks.

The bibliography is arranged, as nearly as possible, on the plan of Popular Science itself, but it has been found desirable to make slight changes in this respect. Ten of the groups correspond with the groups into which Popular Science itself is divided, but it was not thought necessary to include bibliographies of such rather wide and vague groups as Power and Industry and Commerce. Books coming under these heads are, as a rule, quite easily found by those who need them. On the other hand, it was felt that the bibliography called insistently for a section on Philosophy, so closely allied to science in every sense, and one group of books is therefore devoted to the development of Thought. The following are the ten groups into which the books are mainly divided.

1. Universe
2. Earth
3. Life
4. Plant Life
5. Animal Life
6. Man
7. Health
8. Thought
9. Society
10. Eugenics

A moment's reflection will show that any list of this kind is subject to many criticisms, and particularly it must seem that divisions such as these are often arbitrary, or, in any case, a little loose, involving much overlapping. Why is a descriptive study of psychology under Man and another book on psychology under Thought? Why must we look under Earth for books on electricity, side by side with books on the sea? Why is a book on the Ice Age in one section, and a book on the Stone Age in another? The answer to all such questions as these is sometimes that there is no answer, and sometimes that these things are merely the apparent curiosities of any attempt to bring general knowledge into a small number of compartments. It will suffice here to say that the divisions have been fixed for general convenience, and particularly to help those who study scientific things on the lines of this work. As the number of books is so limited it has not been thought necessary to sub-divide each group, as might have been the case if the list of books were longer, but in one or two sections an exception to this rule has been made.

All that is claimed for this bibliography is that it contains about a thousand useful books on all sorts of scientific subjects, with all the essential information necessary to obtain the books without difficulty. The Editor hopes that the usefulness of the list will abundantly justify the space that is given to it, and that a study of these books will encourage that love of knowledge which inspired the conception of Popular Science, which lies behind the editing of it, without which it could not have found a public, and to which it is hoped that these pages now closing have in no small measure contributed.

A SHORT BIBLIOGRAPHY OF SCIENCE

Embracing Brief Synopses of a Thousand Books, with information enabling the reader to obtain them easily

UNIVERSE

Embracing Astronomy, Old and New.

A Primer of Astronomy. By Sir Robert S. Ball. 236 pages. Illustrated. Cambridge University Press .. .. 1s. 6d. net
One of the Cambridge Science Primers. It is a good elementary textbook for beginners and for schools. The author treats of the earth; sun, moon, and planets; gravitation; comets, meteors, etc.; stars and nebulæ. Many excellent illustrations and diagrams.

A Popular Guide to the Heavens. By Sir Robert S. Ball. Illustrated. Philip .. .. 15s. net
This excellent book for beginners and amateurs contains 83 full-page plates, many coloured, being charts of the sun, moon, planetary systems, tides, seasons, comets, nebulæ, the Pleiades, the Milky Way, etc., as well as sectional maps showing the constellations. These plates are beautiful and clear.

The Story of the Heavens. By Sir Robert S. Ball. 568 pages. Illustrated. Cassell .. 10s. 6d.
A complete popular account of astronomy; clear, comprehensive, and interesting. There is no better work for those who are beginning this study. Sir Robert Ball has a peculiar gift for making scientific subjects clear to the "man in the street," and is not in bondage to any narrow theories.

The Story of the Sun. By Sir Robert S. Ball. 361 pages. Illustrated. Cassell .. .. 7s. 6d.
A large work, admirably illustrated, giving a full account of knowledge with regard to the sun up to the time of publication. The book forms a valuable companion to Professor Young's work on the same subject.

Mars and its Canals. By Percival Lowell. 384 pages. Illustrated. Macmillan .. 10s. 6d. net
This popular work gives the history of discoveries with regard to Mars, which have followed one another from 1840 to the present day; describes the chief surface features of the planet, such as the polar caps, and discusses its probable climate. One half of the book is devoted to the "canals," which Mr. Lowell believes to be watercourses surrounded with vegetation. He brings forward strong evidence that these are the work of intelligent beings.

The Evolution of Worlds. By Percival Lowell. 262 pages. Illustrated. Macmillan.. 10s. 6d. net
Describes the birth of a solar system in connection with the appearance of a new star. Tells the story of the initial disaster that occurred to our own system, explains the formation of planets in their self-sustained and sun-sustained stages, and deals with the events that lead to the death of a world.

The Ether of Space. By Sir Oliver Lodge. 156 pages. Illustrated. Harper.. .. 2s. 6d. net
A short book, describing the nature and properties of the ether. Necessarily somewhat technical, but enabling the ordinary reader to realise the wonder of the subject, as, for example: "Every cubic millimetre of the universal ether must possess the equivalent of a thousand tons, and every part of it must be squirming internally with the velocity of light."

Pioneers of Science. By Sir Oliver Joseph Lodge. 397 pages. Illustrated. Macmillan .. 6s.
This book consists of a course of lectures, and presents with admirable clearness the scientific work of some of the great astronomers of our era. Short biographical sketches are also given. Among those treated are Galileo, Kepler, Newton, Laplace, Lagrange, etc.

The Moon. By Richard A. Proctor. 315 pages. Illustrated. Longmans .. .. 3s. 6d.
The motions, aspect, scenery, and physical condition of the moon are here presented with the mixture of graphic writing and mathematical proofs which the author so exceptionally combined. An indexed map of the moon, identifying all her features, is usefully included.

Our Place among Infinities. By Richard A. Proctor. 288 pages. Longmans .. .. 3s. 6d.
A series of brilliant, readable essays, contrasting our little abode in place and time with the infinities around us. Discusses the past and future of the earth, the seeming waste in Nature, lost comets, and the star depths.

Other Worlds than Ours. By Richard A. Proctor. 318 pages. Illustrated. Longmans 3s. 6d.
A discussion of the problem of the plurality of worlds, in the light of scientific researches. Propounds views differing from those usually accepted, and comes to the conclusion that the number of inhabited worlds in the universe must be small.

Other Suns than Ours. By Richard A. Proctor. 419 pages. Illustrated. Longmans .. 3s. 6d.
A series of popular discussions on suns—old, young, and dead. Deals with new stars, the birth of worlds, the origin of comets, and other astronomical subjects, but includes some scientific essays on miscellaneous topics.

Worlds in the Making. By Svante Arrhenius. English translation by H. Borns. 229 pages. Illustrated. Harper .. .. .. 6s.
A study of many astronomical subjects, including volcanic phenomena; the celestial bodies as abodes of organisms; the radiation and constitution of the sun; polar lights; terrestrial magnetism the origin of nebulæ, etc.

The Stars. By G. F. Chambers. 192 pages. Illustrated. Hodder and Stroughton .. 1s. net
A popular introduction to the stars, their brilliancy and distance, number, movements, and relations with one another, and to all the varieties of stars and nebulæ now known; for those, especially, who do not so far know them. The author tells of double stars, coloured stars, temporary stars, variable stars, groups of stars, clusters of stars, nebulæ, the Milky Way, and, finally, of the stars and nebulæ as known to the spectroscope. A table of the constellations is given in the appendix, as also a list of objects to be seen in small telescopes.

A READER OF LONG AGO—FROM A PORTRAIT

ROMNEY'S PORTRAIT OF MISS SNEYD, ENTITLED "SERENA," AND NOW HANGING IN THE SOUTH KENSINGTON MUSEUM

The Science of the Stars. By E. W. Maunder. 92 pages. Jack .. .. 6d.
A gallant attempt to cover this vast subject in a few pages, which has achieved remarkable success. The little book deals with astronomy before history; astronomy before the telescope; the law of gravitation; astronomical measurements; the members of the solar system, and the system of the stars.

The Sun. By Charles G. Abbot. 448 pages. Illustrated. Appleton .. .. .. 7s. 6d. net
This book, by one of the leading American astronomers, is a record of the discoveries of the last fifteen years or so with regard to the sun, which is treated under three chief aspects—(1) as the controlling member of the solar system; (2) in its own nature, especially as the nearest star, and typical of many stars; (3) as the fountain of light and heat, and so of life on the earth. Also gives an account of methods and principles of present-day solar research.

Astronomical Discovery. By Herbert H. Turner. 225 pages. Arnold .. .. .. 10s. 6d.
The following discoveries are here considered in their relation to, and bearing upon, astronomy in general: (1) Uranus and Eros; (2) Neptune; (3) Bradley's discoveries of aberration and nutation; (4) accidental discoveries; (5) the sun-spot period; (6) the variation of latitude. The chapter on Bradley is particularly pleasing, especially the picture of the astronomer Pound, Bradley's uncle.

History of Astronomy. By W. W. Bryant. 355 pages. Illustrated. Methuen .. 7s. 6d. net
A general history from 3000 B.C. to the present day. It does not enter into details, but sketches the main course of progress, as well as the development of observatories, telescopes, and other instruments. Mr. Bryant is superintendent of the magnetical and meteorological department of Greenwich Observatory.

The Story of the Comets. By G. F. Chambers. 256 pages. Illustrated. Clarendon Press 6s. net
The best popular account of comets and meteors, dealing with every aspect of the subject. A good bibliography.

The Growth of a Planet. By Edwin Sharpe Grew. 351 pages. Illustrated. Methuen .. 6s.
In this work the author brings together the modern theories, astronomical, physical, geological, geographical, and biological as to the origin, formation, and growth of the members of the solar system. The "spiral hypothesis" of development from spiral nebulæ is adopted by the author, who traces the history of the nebulous knot through various stages up to the point in habitation by organic life at which man appears.

The Solar System. By Charles Lane Poor. 310 pages. Illustrated. Murray .. .. 6s. net
This book gives an account of the recent additions to our knowledge of the solar system. Considerable space is devoted to the study of the tides and of tidal evolution; also to the problems connected with the planet Mars. The sun, the moon, the planetary motions, satellite systems, comets, meteors, the evolution of the solar system, and a careful exposition of the "spiral hypothesis" are included.

Astronomy. By Arthur R. Hinks. 256 pages. Williams and Norgate .. .. .. 1s.
The author, who is chief assistant at Cambridge Observatory, gives a short sketch of the present condition of astronomical knowledge in relation to the sun, moon, planets, comets, meteors, stars, nebulæ, the Milky Way, and the law of gravity. The methods of observation are explained, and the uses of astronomy in daily life described.

Astronomy during the Nineteenth Century. By Agnes M. Clerke. 489 pages. Ill. Black. 7s. 6d. net
A very able and popular history of the science during the last century. It traces the development in every department; as in our knowledge of the stars and the construction of the heavens, of the planets and their satellites, of comets, of nebulæ, and of the physical and other relations of the heavenly bodies. It also describes the enormous advances in instrumental resources. There are biographical sketches of many leading astronomers.

The Moon. By James Nasmyth and James Carpenter. 213 pages. Illustrated. Murray .. 5s. net
For many years the standard work on the subject; now needs to be supplemented by a modern treatise, such as Professor Pickering's. The moon is considered as a planet, as a world, and as a satellite.

The Tides. By Sir George Howard Darwin. 437 pages. Illustrated. Murray .. 7s. 6d. net
The standard work on this interesting subject, treating of the practical methods of observing and predicting the tides, and showing the degree of success which it is possible to obtain in predictions. The account, while being thoroughly scientific, is eminently clear and readable, and not technical. Later chapters deal with several problems of speculative astronomy, such as cosmical time, Saturn's rings, and the origin of double stars.

History of the Planetary Systems. By John Louis Emil Dreyer. 443 pages. Cambridge University Press .. .. 10s. 6d. net
This book is a profound and interesting study of the progress of astronomical knowledge and theory. It traces the history of thought from Thales to Kepler, by whom the Copernican system was established on a firm and scientifically demonstrated basis. The study of the older systems is peculiarly clear and sympathetic.

Astronomy of Today. By C. G. J. Dolmage. 363 pages. Illustrated. Seeley .. 5s. net
A popular yet truly scientific work, dealing with the whole subject in the light of recent discoveries, and in language free from technical expressions. Describes the sun, moon, and planets; comets and meteors; the stars and their system, and the structure of the heavens. Ancient astronomical theories and the principles of telescopic observation are also explained. The illustrations are excellent.

Astronomy. By Frank Watson Dyson. 247 pages. Dent .. .. 2s. 6d. net
This little book, by the present Astronomer Royal of Greenwich, is intended to present to the ordinary reader the principles and methods upon which astronomers proceed, and the reasons for some of the important propositions

they advance. The author discusses ancient astronomy and astronomical instruments at some length, and then proceeds to speak of the sun, the solar system, stars of all kinds, nebulæ, and the sidereal universe.

The Starry Skies. By Agnes Giberne. 242 pages Illustrated. Seeley .. .. .. 1s. 6d.
A famous little primer of astronomy, divided into lessons, with questions at the end of each. An elementary textbook, suitable for children.

Textbook of General Astronomy. By Charles A. Young. 630 pages. Illustrated. Ginn 12s. 6d.
The best general textbook, being an introduction to the whole subject. Explains the principles of astronomical science and observation; the methods and instruments of practical astronomy; and treats of the nature and movements of the heavenly bodies.

Astronomy. By G. F. Chambers. 335 pages. Illustrated. Hutchinson .. .. 5s. net
An excellent popular outline of the whole subject. Not a formal treatise, nor an educational textbook. Designed especially for use with a telescope of two or three inches aperture.

The Solar System. By G. F. Chambers. 202 pages. Illustrated. Hodder and Stoughton 1s. net
A book designed especially for observers who possess or have access to "popular telescopes," i.e., those of from two to four inches of aperture, and costing any sum between £10 and £50. The author cites the example of an astronomer who discovered fourteen minor planets from an attic window, with an instrument of only two and a half inches aperture. But the work is valuable also for those who never use a telescope at all. It describes in popular language the sun, moon, each of the planets, and the principal comets.

Through the Telescope. By Rev. J. Baikie. 292 pages. Illustrated. Black .. .. 5s.
An excellent introduction to astronomy, with special reference to practical study of the heavens with small and inexpensive telescopes. The language is simple, and the book is intelligible throughout to any person of ordinary education. The illustrations represent for the most part the results of the best modern instruments, but a few are included to show the work of small telescopes.

Eclipses. By G. F. Chambers. 254 pages. Illustrated. Hodder and Stoughton .. 1s. net
A little work giving all that the general reader needs to know about eclipses of the sun and moon, transits and occultations.

Practical Astronomy. By Hector Macpherson Jun. 94 pages. Diagrams. Jack .. .. 6d.
A simple guide to the heavens for all who know little or nothing of astronomy, telling, in clear and simple language, how to recognise the stars which may be seen with the unaided eye, and the constellations to which they belong, and how to locate them at different seasons of the year.

A History of Astronomy. By Arthur Berry. 440 pages. Illustrated. Murray .. 6s.
One of the University Extensions Manuals, intended for the general reader. The author traces the history of astronomical science from primitive times, and reviews the life and work of the great pioneers, such as Hipparchus, Ptolemy, Copernicus, etc. Details not bearing on the development of the science, as well as merely speculative theories, have been omitted, and the book thus presents clearly the main stream of astronomical history.

Handbook of Descriptive Astronomy. By G. F. Chambers. 3 vols. Ill. Clarendon Press. 32s. net
Contains an enormous amount of information. Vol. I. deals with the sun, planets and moon; the zodiacal light; eclipses, transits, occultations; tides, aberration and refraction; comets, meteors, etc. Vol. II. describes astronomical instruments and their use. Vol. III., which is supplied separately at 8s. 6d. net, is concerned with a survey of the stars, constellations, Milky Way, and nebulæ.

The Moon. By William Henry Pickering. Illustrated Doubleday, Page & Co. .. £2 10s.
This book contains over a hundred full-page plates, including 84 most beautiful photographs, forming a complete atlas of the moon. The page being very large, the plates are exceptionally valuable and beautiful. Only the more recent advances in the knowledge of the moon are dealt with.

The Birth of Worlds and Systems. By A. W. Bickerton. 162 pages. Harpers .. .. 2s. 6d. net
A short and popular work on a new theory of the death and regeneration of the parts of the universe. Professor Bickerton thinks that dead suns partly collide, and give rise to new fiery stars. The light gases given off by worlds collect in space and form a sort of star mist, and attract dead, burnt-out suns, and new systems are thus born.

The Stars: A Study of the Universe. By Simon Newcomb. 333 pages. Illustrated. Murray. 6s. net
In this volume the author attempts to sketch, in simple language for the average reader, the wonderful advances of our generation in the knowledge of the fixed stars. He admits that to do this without entering into technical details, and yet to retain precision of statement, is next to impossible; but he succeeds in giving a striking general survey of recent knowledge.

Modern Astronomy. By Herbert H. Turner. 302 pages. Illustrated. Constable .. .. 2s. 6d. net
Shows how powerfully astronomy has been affected by the invention of the photographic dry-plate and other scientific events of the last thirty-five years. Describes the instruments of the revolution of astronomical science, the methods based upon them, and the results obtained. The writer is the Professor of Astronomy at Oxford, and he writes in a clear and simple diction.

Man's Place in the Universe. By Alfred Russel Wallace. 341 pages. Chapman and Hall. 6s.
An unorthodox book by a great man, contending that the earth holds practically a central position in the universe, that this position has been favourable, and perhaps essential, to the development of life on the earth, and that earth is the only inhabited world. Dr. Wallace discusses the results of scientific research in relation to the unity or plurality of worlds, and considers such questions as: Are the stars infinite? our relation to the Milky Way

physical conditions of life; are the stars useful to us? and so on, and in later editions he has added a chapter supporting his theory by arguments from Evolution—upon which subject he must, of course, be held a supreme authority. Dr. Wallace's conclusions on this subject are not generally accepted, and they clearly challenge views now widely held as to the possibility of life in other worlds; but the theory of this volume is enthralling in its human interest, and the right of the author to be heard is beyond all question.

The Life of the Universe. By Svante Arrhenius. Two volumes. Harper .. .. 5s. net
A history of evolution theories, which shows "how the grand speculations of our age have been evolved from the primitive, child-like, and inherent notions of our ancestors in bygone ages," so that we trace the rudiments of our modern theories from the shadowy notions of antiquity.

The Meteoritic Hypothesis. By Sir Norman Lockyer. 559 pages. Illustrated. Macmillan 17s. net
Contends that many so-called stars are swarms of meteorites, and that all self-luminous bodies in the celestial spaces are composed either of swarms of meteorites or of masses of meteoritic vapour, produced by heat, while many solar phenomena are produced by the fall of meteorites upon the surface of the sun.

Two New Worlds. By E. E. Fournier d'Albe. 159 pages. Longmans .. .. .. 3s. 6d. net
An attempt to penetrate the mystery of space and time, with the help of the most modern resources of scientific research. The main thesis is that a universe on a similar pattern to ours exists on a very small scale, and another on a much larger scale—the one being the minute world in which atoms and electrons stand for suns and planets, and the other stellar systems beyond the Milky Way.

Total Eclipses of the Sun. By Mabel L. Todd. 285 pages. Illustrated. Sampson, Low .. 8s. 6d.
A book written for the general reader, in non-technical language, explaining why eclipses occur, commenting on examples of the past and present, with a forecast of what may be expected during the next sixty years.

The Sun's Place in Nature. By Sir Norman Lockyer. 360 pages. Macmillan .. .. 12s.
Gives a first-hand account of one of the most wonderful discoveries in chemistry—the element helium—and tells how it was afterwards found on our planet. Discusses the sun's place among the stars, and the origin of new stars, in connection with the author's meteoric theory.

The Chemistry of the Sun. By Sir Norman Lockyer. 457 pages. Illustrated. Macmillan .. 12s.
A classic work, by the discoverer of the new element helium. Deals mainly with the application of spectroscopic methods and photographic records in determining the substances flaming in the centre of our solar system.

PRICES OF BOOKS

It should be remembered that in practically all cases, whether stated or not, the price of shilling and sixpenny books is *net*. "Cheap editions" indicates that several editions exist.

EARTH

Embracing Geology, Geography, Exploration, Meteorology, Physics, Chemistry, Electricity, Radium.

GEOLOGY AND KINDRED SUBJECTS

Textbook of Geology. By Sir Archibald Geikie. Two vols. 1474 pages. Illustrated. Macmillan. 30s.
The best work by any British author reviewing the whole of geology. Though very learned, it is simple and readable; the author's great interest in scenery always makes his work attractive. The chief divisions of the book are: The cosmical aspects of geology; geognosy, or the inquiry into the materials of the earth's substance; dynamical geology; structural geology; palæontological geology; stratigraphical geology; physiographical geology. There is a good bibliography, and a list of geological maps of all parts of the world.

Classbook of Geology. By Sir Archibald Geikie. 475 pages. Illustrated. Macmillan .. 5s.
The standard introductory work on the study of the structure of the earth. Clearly and simply written, and suitable for the general reader as well as for the young student.

The Founders of Geology. By Sir Archibald Geikie. 497 pages. Macmillan.. .. .. 10s. net
A history of the development of geological science in the form of a series of life-stories of the pioneers and masters of geology. Combines brilliance of style with solidity of thought.

Landscape in History, and Other Essays. By Sir Archibald Geikie. 352 pages. Macmillan. 8s. 6d. net
Half of the essays deal with scenery in its relation to geological events, and in its influence on human progress; the work brings home to the mind in a vivid way the value of geology.

The Scenery of Scotland Viewed in Connection with its Physical Geology. By Sir Archibald Geikie. 560 pages. Illustrated. Macmillan .. 10s. net
Begins by describing the general processes by which land is sculptured into changing shapes, and then gives particular examples of the work of geological forces in the highlands, the southern uplands, and the valleys in the midlands. Brings home to the observing reader the might of the silent powers around him.

Earth Sculpture; or the Origin of Land Forms. By James Geikie. 336 pages. Illustrated. Murray. 6s.
A simple but scientific account, for general readers, of the processes by which the land is carved out and moulded and changed by internal fires and glaciers of the Ice Age. An authoritative study of the origin of scenery.

Structural and Field Geology. By James Geikie. 452 pages. Illus. Oliver and Boyd. 12s. 6d. net
For beginners in field geology. Deals with rock-forming minerals, rocks, fossils, and the formation of rock-beds, ore-formation, geological surveying, and the industrial and practical aspects of geological structure are explained in some detail. Chapters on soils and subsoils and the evolution of surface features.

Outlines of Geology. By James Geikie. 436 pages. Illustrated. Stanford .. .. .. 12s.
An introduction for general readers. The parts which the beginner usually finds difficult are

treated in greater detail. Gives a broad view of the scope and bearing of the science, with a table of British strata in which fossils are found, and a glossary of terms.

Prehistoric Europe. By James Geikie. 592 pages. Illustrated. Stanford .. .. .. 25s.
An outline of the chief physical changes on the Continent of Europe since the beginning of the Pleistocene period. The successive changes of climatical and geographical conditions are examined systematically.

The Scenery of Switzerland. By Lord Avebury. 473 pages. Illustrated. Maps. Macmillan 6s.
A brilliant little book on the geological processes which have been at work in producing the Swiss scenery. Lord Avebury, who travelled in Switzerland in the company of Tyndall and Huxley, and later spent many holidays in the Alps, has a keen eye for natural grandeur and beauty, and succeeds in showing how the physical features of the country are produced and how they are changing.

Ice-work, Present and Past. By T. G. Bonney. 295 pages. Illustrated. Kegan Paul .. 5s.
An interesting book because of its distinct aim and individuality. Professor Bonney here tries to give prominence to all those facts of glacial geology on which all inferences must be founded, and he selects for description such phenomena as he has examined personally, assuming in all controversial matters, he claims, the attitude of a judge rather than of an advocate. The result is a fine collection of materials for forming a judgment as to the part played by ice in the story of the world.

Structure of the Earth. By T. G. Bonney. 94 pages. Jack .. .. 6d.
A popular introduction to the subject, by one of the greatest living British geologists, dealing with the problems and methods of geology; the earth's constitution and age; the work of heat and cold; of rain and running water; of snow and ice; the work of the sea; volcanoes and their lessons; movement of land and their results, and the life-history of the earth.

A Study of Recent Earthquakes. By Charles Davison. 355 pages. Illustrated. Walter Scott 6s.
An interesting collection of accounts of earthquakes in all parts of the world, covering very wide ground, and bringing together facts not previously collected in one volume. The final chapter gives a summary of the results of earthquake study.

The Geological History of Plants. By Sir J. William Dawson. 290 pages. Illustrated. Kegan Paul. 5s.
The object of the writer is "to give in a connected form a summary of the development of the vegetable kingdom in geological time." Born in a district rich in fossil plants, he began as a boy the study summarised in this book, and continued it for nearly half a century. The way is made easy in an introductory chapter by a condensed geological chronology.

The Story of the Earth and Man. By Sir J. William Dawson. 411 pages. Illustrated. Hodder. 7s. 6d.
A popular treatise of the science of the earth, as illustrated by geological research—the genesis of the earth; the Eozoic Ages; the Primordial or Cambrian Age; the Silurian Age, and so on, through the successive stages, until the close of the post-Pleoicene and the advent of man. Then follows an account of primitive man.

The World's Foundations. By Agnes Giberne. 315 pages. Illustrated. Seeley .. .. 5s.
A popular book on geology, for beginners. Would do for children above fourteen.

First Lessons in Modern Geology. By A. H. Green. 212 pages. Illustrated. Clarendon Press 3s. 6d.
A book arranged, for education purposes, in lessons, such as, for example: "What sandstone is made of"; "About coal, and how it was made"; "About crystals"; "How the surface of a country is affected by its geology"; "About fossils—how they are preserved and what they teach us." Popular, but scientific.

The Making of the Earth. By J. W. Gregory. 256 pages. With maps. Williams and Norgate 1s.
The sum of evidence as to the origin of the earth, provided by the latest astronomical, geological, palæontological, zoological, and geographical researches is here brought together. The last chapter is a consideration of the origin of life, which the author defines as the problem of "the formation of a self-generating, reproductive, carbonaceous jelly, of such a nature that it served as the beginning of the whole of the organic evolution that followed."

The Romance of Modern Geology. By E. S. Grew. 308 pages. Illustrated. Seeley .. 5s.
An account in simple language of the building of the earth, and of the various processes which have been at work producing its present features; with some account, in an interesting manner, of prehistoric animals. Suitable for children over fourteen, and for older readers who are not specialists.

The Natural History of Igneous Rocks. By Alfred Harker. 384 pages. Illus. Methuen. 12s. 6d. net
This book contains the substance of a course of lectures by the author, who is Professor of Petrology in the University of Cambridge. It is a work for serious students, but eminently readable. Igneous action and igneous rocks are first considered from a geological standpoint and brought into their proper relation with other parts of historical geology. The middle part of the book deals with the crystallisation of igneous rock-magmas. Finally, the genesis of igneous rocks is considered, and in the last chapter a natural classification of these rocks is attempted.

Textbook of Petrology. By F. H. Hatch and R. H. Rastall. 425 pages. Illustrated. George Allen. 7s. 6d.
A very valuable but highly scientific description of the sediments and their metamorphic derivatives. A useful contribution to a branch of geology which has perhaps been rather neglected. There is a most useful appendix, in which Mr. T. Crook admirably summarises the modern methods of separating and determining the minerals occurring in clays, sands, and soils.

The Story of the Hills. By Rev. H. N. Hutchinson. 356 pages. Illustrated. Seeley .. 5s.
In this book the author sets out to tell, in a popular manner, the story of mountains and how they were made, having in mind the thousands who are now able to visit the moun-

tains of Europe during their holidays, and the ladies who climb Mont Blanc, or wander among the Carpathians. For such readers the scientific facts and history of mountains are genially rendered in this excellent work.

Volcanoes. By John W. Judd. 381 pages. Illustrated. Kegan Paul .. .. .. 5s.
A popular exposition of the present condition of knowledge respecting volcanoes, with an account of investigations that in recent times have thrown fresh light on the whole problem. These investigations include the character of lavas, as revealed by miscroscopic examination; the nature and movements of liquids enclosed in the crystals of igneous rocks, and the relation of minerals in volcanic products to those found in meteorites.

The Student's Lyell; Principles and Methods of Geology. 645 pages. Illustrated. Murray. 7s. 6d. net
An epoch-making work in the history of geological science. Sir Charles Lyell was the pioneer of the theory that the changes still in progress are chiefly such as have produced the former changes of the earth's surface, and in these volumes covers the whole ground of geology, as known in his day, in the light of this principle. Besides dealing with the face of the earth, Lyell treats of climate and of astronomical changes in their relation to the earth's features; of aqueous and glacial causes of change; of rivers, tides, and currents; of igneous causes, etc. He also deals with flora and fauna, the antiquity of man, the origin of species, and a host of other interesting and kindred subjects.

The Scientific Study of Scenery. By John E. Marr. 372 pages. Illustrated. Methuen .. 6s.
This book is intended as an introduction to the scientific study of the existing features of earth, sea, and sky which are visible to the eye; it deals chiefly with the attribute of form and its causes, but also with size, colour, movement, and character of surface.

A Piece of Coal. By E. A. Martin. 196 pages. Illustrated. Hodder and Stoughton.. 1s. net
Coal is a mineral of many-sided interest. It originates in plant life, matures in geological strata, is mined in one of our greatest industries; as fuel, supports most other industries, affords heat to our homes, produces gas for illumination, and is the source of the most brilliant dyes of commerce. All these and other aspects of a piece of coal are admirably told in this little book, well illustrated by the author.

Mineralogy. By Sir Henry A. Miers. 584 pages. Illustrated. Macmillan .. .. 25s. net
This "introduction to the scientific study of minerals" is an admirably written and illustrated work, valuable especially with regard to the crystalline structure of minerals. The book will be found interesting by every student of the rocks, and even by the beginner.

History of Geology and Palæontology. By K. von Zittel. 362 pages. Portraits. Scott 6s.
No science has had a more rapid and changeful growth than geology. That growth to the end of the nineteenth century is here traced by the distinguished Professor of Geology in the University of Munich, with remarkably wide knowledge and a complete acquaintance with the personal story that is interwoven with the development of the science. Dr. von Zittel not only tells how the knowledge is accumulated, but, step by step, names the people who have been its collectors. An invaluable book.

The Earth in Past Ages. By H. G. Seeley. 196 pages. Illustrated. Hodder and Stoughton 1s.
This useful little book tells the story of the earth in the past in such a manner as to explain its present condition. It explains the nature of the common materials which form rocks, the ways in which they rest on one another, and the means by which they may be distinguished. Fossil remains are explained in a similar manner with reference to the life which now exists.

Man and the Glacial Period. By G. Frederick Wright. 385 pages. Illustrated. Kegan Paul 5s.
The author summarises the position of existing glaciers; discusses glacial motion, and signs of past glaciation; locates the ancient glaciers of both hemispheres, and outlines their drainage systems; points out where the relics of man are found in connection with the glacial period, and debates the cause and date of that period.

The Scenery of England, and the Causes to which it is Due. By Lord Avebury. 560 pages. Illustrated. Macmillan .. .. 6s.
Attributes the configuration of England, and consequently the scenery, mainly to sub-aerial action. A work on the principles of geology, written in a fresh and vivid manner. Deals with the Great Ice Age, the sculpture of the coast, the origin of the mountains and lakes, and the history of English rivers, fens, downs, and commons.

The Work of Rain and Rivers. By T. G. Bonney. 144 pages. Illustrated. Cambridge University Press .. .. 1s. net
Dr. Bonney has written this short account of the work of rain and rivers in such a way as to apply the principles of this branch of geology to the interpretation of scenery. The book is particularly interesting to readers who have travelled, for the illustrations are all drawn from much-frequented districts.

Volcanoes: their Structure and Significance. By T. G. Bonney. 378 pages. Illustrated. Murray. 6s.
A simply written but authoritative book on the subject. Describes the activities of a living volcano from birth to death. Deals with the geological history of British volcanoes, and the distribution of volcanoes over the earth in the past and present. A general survey of the problems of volcanic action.

Descriptive Meteorology. By W. L. Moore. 344 pages. Illustrated. Appleton .. .. 12s. 6d.
A study of the known forms of energy that reach the earth from the sun, and of those parts of the earth that absorb, radiate, conduct, and reflect heat. A general introduction to the modern science of the weather.

The Old Red Sandstone. By Hugh Miller. 363 pages. Dent .. .. 1s. net
The story of how the author found fossils in the lower old red sandstone, and fixed in the geological scale the place to which the larger beds of remains found in the system belong. Some of

the work of Miller has been superseded by later and wider experience, but his book will always live because of the imaginative power he used in picturing the vanished past.

Petrology for Students: Study of Rocks under the Microscope. By Alfred Harker. 336 pages. Illustrated. Cambridge University Press .. 7s. 6d.
A guide to the study of rocks in thin slices, that needs to be supplemented throughout by demonstrations on actual specimens. Designed for English-speaking students, and dealing with British, American, and Colonial rocks. A useful book on a comparatively new study.

The Natural History of Clay. By A. B. Searle. 176 pages. Illus. Cambridge University Press. 1s. net
Though clay is so useful, and long has been, we know little of its properties when in a pure state. This volume outlines what is known, and indicates unsolved problems. For instance, many clays owe their chief value to plasticity, but plasticity is of a very elusive nature, and almost defies measurement. Mr. Searle is particularly competent to introduce these questions and indicate the lines of future knowledge.

Natural History of Coal. By E. A. N. Arber. 156 pages. Illus. Cambridge University Press. 1s. net
There was a time when scientific men regarded the natural history of coal as a simple matter. Not so now. It is crowded with unsolved problems. This Mr. Arber realises. He sees that all types of coal were not derived from the same type of "mother substance." So he does not dogmatise, but states theories fairly while considering the conditions under which different coals have accumulated.

The Geology of Coal and Coal-Mining. By Walcot Gibson. Illustrated. 341 pages. Arnold. 7s. 6d. net
Deals in an elementary manner with the strictly scientific side of the subject, and explains all the geological terms used by miners. Describes formation and origin of coal, the art of prospecting and boring, and surveys the coalfields of Britain at length, and the coalfields of the rest of the world in a more concise manner.

An Introduction to Geology. By J. E. Marr. 229 pages. Illus. Cambridge University Press 3s. net
An attempt to explain the scope and methods of geology without using technical terms or taxing the reader's memory with excess of detail. Useful to general readers who wish to obtain some idea of the science, and especially instructive to the student who intends to proceed to the reading of more advanced treatises.

The Geology of Water-Supply. By Horace B. Woodward. 339 pages. Illustrated. Arnold. 7s. 6d.
Deals with the knowledge of the geological structure of the ground and the character of rock-formation necessary in obtaining an adequate supply of potable water. Study of water-bearing strata, springs, underground sources, with a chapter on prospecting for water. Written with special reference to Great Britain, but touches other water supplies.

Gem-Stones and their Distinctive Characters. By G. F. H. Smith. 312 pp. Illustrated. Methuen. 6s. net
A concise and yet complete account of the characters of the minerals used in jewellery. The author describes fully the methods of determining the chief qualities of gems, so that the reader, even if previously unacquainted with the subject, may have at hand all the information necessary for the identification of any cut stone.

The Geology of Building Stones. By J. Allen Howe. 455 pages. Illustrated. Arnold .. 7s. 6d. net
A practical book of reference for architects and students of geology. Gives a list of the principal granite, sandstone, limestone, and slate quarries, and deals generally with the building stone resources of our country.

Mineralogy. By F. H. Hatch. 253 pages. Illustrated. Whittaker .. .. .. 4s. net
Dealing with the characters of minerals, their classification and description. The first part treats of the forms, physical properties, and chemical composition of minerals; the second part describes the rock-forming groups—the ores, salts, gems, and other varieties. Only those minerals that play an important rôle in the economy of Nature, or are used by man, are described at length.

The World's Minerals. By L. J. Spencer. 212 pages. Illustrated. Chambers .. 5s.
All the more common, simple minerals are described, and are illustrated on coloured plates. The author has avoided, as far as possible, technical terms, and has used popular language suited for younger students.

Rocks and their Origins. By G. A. J. Cole. 175 pages. Illus. Cambridge University Press. 1s. net
An introduction to geology for the general reader, discussing simply and clearly first rocks in general, and then, in separate chapters, limestones, sandstones, clays and slates, igneous rocks, and metamorphic rocks. There is a useful bibliographical reference table.

The Face of the Earth. By Edward Suess. Translated by Hertha B. C. Sollas. Illustrated. Four volumes. Clarendon Press .. .. £4 13s. net
The most complete and definite of all the general surveys of geological facts. It embodies the results of personal research, and a study of the work of the leading geologists of all lands, and it approaches nearer absolute comprehensiveness and authority than any similar work in any language.

Geology. By Thomas C. Chamberlin and Rollin D. Salisbury. Three vols. Illus. Murray. 21s. net
A brilliant American work, in which the authors approach the science by a study of the forces and processes now in operation. Encumbered as little as possible by technicalities and unimportant details, but immense in sweep, and intimate in style. Rather too large a work for a general reader to start on, but very valuable and stimulating to advanced students.

The Age of Earth. By Arthur Holmes. 196 pages. Illustrated. Harper .. .. 2s. 6d. net
Approaches the subject from various sides, dealing with tidal effects, the saltness and age of the oceans, the work of denudation, and the time required for the formation of sedimentary rocks. Discusses the new factor of radio-active substances, which is upsetting both mathematicians and geologists.

Causal Geology. By E. H. L. Schwarz. 248 pages. Illustrated. Blackie .. .. .. 7s. 6d. net. The author here sets forth the results of ten years' observation on the geological survey of Cape Colony. The facts presented by this country led him to conclusions similar to the planetismal hypothesis advanced by Professor Chamberlain, the brilliant American geologist.

GEOGRAPHY AND KINDRED SUBJECTS.

Elementary Lessons in Physical Geography. By Sir A. Geikie. 363 pages. Ill. Macmillan. 4s. 6d. A simple but systematic and interesting description of the familiar features of the surface of the earth. The earth as a planet; the air and its properties; the sea—its movements and offices; the land, and the geographical distribution of the various forms of life.

Structure and Distribution of Coral Reefs. By Charles Darwin. 344 pages. Illustrated. Smith, Elder. 8s. 6d. Discusses the origin of the main kinds of coral reefs. Argues that both in atoll and barrier reefs the foundation to which the coral was primarily attached has subsided, and that during this downward movement the reef-forming organisms have built upwards.

Voyage of the Beagle. By Charles Darwin. Cheap ed. Darwin himself said: "The voyage of the Beagle has been by far the most important event in my life, and has determined my whole career." Not only does it form an introduction, in spirit, to scientific study, but it is one of the most readable books of travel.

Polar Exploration. By William S. Bruce. 254 pages. Williams and Norgate .. 1s. Mr. Bruce, who has himself explored in the Arctic and Antarctic regions, and directs the Scottish Oceanographical Laboratory, Edinburgh, here deals not with the history of Polar adventure, but with the physical and biological conditions of Polar regions. Chapters are devoted to land ice, sea ice, plant and animal life, meteorology, aurora, magnetism, and other aspects of polar geography.

History of the Thermometer. By Henry Carrington Bolton. 96 pages. Williams and Norgate. 4s. 6d. Traces the successive steps in the history of the evolution of the thermometer from its first beginnings in Italy at the end of the sixteenth century, through its crude early forms, down to the three standards now commonly used in all civilised lands. With a chronological epitome and a comprehensive list of authorities. A little volume packed with facts.

Labrador Journal. By Capt. Cartwright. Illustrated. Williams and Norgate .. 5s. net This work, with an introduction by Dr. Grenfell, the intrepid missionary, gives extremely able descriptions of animals and their ways, but also has much human interest.

Cook's Voyages of Discovery. 479 pages. Dent. 1s. net James Cook, the intrepid seaman and explorer, undertook three great voyages. The narrative of all three is of absorbing interest.

The Weather. By G. F. Chambers. 234 pages. Illustrated. Hodder and Stoughton .. 1s. net This little book, reviewing the principal facts of meterology, and giving some hints "how to become a weather-prophet," is entirely practical in its intention. "The question of the weather of tomorrow, or of the day after, has often a very important bearing on the business and pleasures and health and convenience of all classes of the community." The use of weather-charts, barometer, thermometer, hydrometer, rain-gauge, weather-cock, and anemometer, sunshine-recorder, and other instruments is made clear.

Climate and Weather. By H. N. Dickson. 252 pages. Williams and Norgate .. 1s. An excellent study of the atmosphere, illustrated by maps and diagrams; the influence of land and sea; the various climatic regions; climate and vegetation, and climate and man.

Tropical Africa. By Henry Drummond. 242 pages. Illustrated. Hodder and Stoughton .. 3s. 6d. One of the travel books that becomes literature through the freshness of the traveller's sight, and his power of investing whatever he writes with an incommunicable charm.

Narrative of a Journey to the Shores of the Polar Sea. By Sir John Franklin. 434 pages. Dent. 1s. net This account, by the great explorer himself, of the first expedition of which he was in supreme command, to attempt the discovery of the North-West Passage to the Pacific, was published in the year following his return. He made two later attempts, in the last of which he and all his party perished, in 1847.

The Ocean of Air. By Agnes Giberne. 334 pages. Illustrated. Seeley .. .. .. 5s. An excellent account of meteorology for beginners. Very readable; any child over twelve would delight in it and learn much from it.

The Romance of the Mighty Deep. By Agnes Giberne. 290 pages. Illustrated. Seeley 5s. A popular account of the ocean and the laws by which it is ruled, of its wonderful powers, and its strange inhabitants, given in the form of romantic narrative.

Geography. By J. W. Gregory. 305 pages. Illustrated. Blackie .. .. .. 6s. net This book, by the Professor of Geology in Glasgow University, gives the most important facts concerning the structural geography of the earth, and the evolution of our present continents from older lands. The use of geological terms is avoided, but the geological horizons are defined and occasionally referred to. A useful and delightful book for schools.

Central Asia and Tibet. By Sven Hedin. Two vols. Illustrated. Maps. Hurst and Blackett. £2 2s. The stirring story of Sir Hedin's second great journey through Central Asia. The route was from Stockholm to Kashgar; from Yarkand-daria a boat-journey through the desert down the lonely river Tarim; across the Takla-Makan Desert—"The Land of Perpetual Twilight"; to Lop-nor and its sister lakes; in Northern Tibet, a land of mountains, lakes, and quagmires at high altitudes; across the appalling Desert of Gobi; to the ruined towns of Lou-lan; a most adventurous and dangerous dash for the holy city of Lassa, and home by India and Kashgar.

Overland to India. By Sven Hedin. Two vols. Illustrated. Maps. Macmillan .. £1 10s. net A route, by unfrequented ways, through the "ancient, desolate, and effete Persia." The

journey begins from Teheran, and passes through unrelieved desert all the way to India. Of course, there are frequent signs of wonderful old forgotten civilisations. One of the most interesting of Sir Sven Hedin's results has been to confirm the accuracy of Marco Polo, who was so long unjustly regarded as a romancing and somewhat legendary traveller.

Volcanoes Past and Present. By Edward Hull. 270 pages. Illustrated. Walter Scott .. 3s. 6d.
A popular account of the volcanic and seismic phenomena of the globe as manifested in certain notable eruptions. The book endeavours to find an answer to two important questions: Are we living in an epoch of extraordinary volcanic energy? and What is the ultimate cause of volcanic action?

The Opening-Up of Africa. By Sir H. H. Johnston. 254 pages. Williams and Norgate .. 1s.
This excellent little historical summary of the development of the Dark Continent is well illustrated with maps. Many readers will be surprised to find how much was known of Africa before modern times. The work of Greeks, Romans, Moslems, Portuguese, and Dutch forms a story of absorbing interest.

Weather Science. By R. G. K. Lempfert. 94 pages. Illustrated. Jack .. .. .. 6d.
A sound popular introduction to meteorology. The art of forecasting the weather is shown in a very interesting way. The study of the upper air, which is the subject of the last chapter, deserves increased attention in the interests of the modern study of aeronautics.

Modern Geography. By Marion I. Newbigin. 248 pages. Williams and Norgate .. 1s.
Miss Newbigin, who has also done good work as a zoologist (see books on Animal Life), studies in this volume the leading questions of physical, biological, and sociological geography. It is an admirable piece of work, and contains a good little bibliography.

Travels of Mungo Park. Cheap editions.
The story of the great explorer's travels in the interior of Africa, his attempt to find the River Niger, his adventures and escapes, with his success in attaining his object, and the further difficulties and mishaps which attended his homeward journey. These adventurous explorations took place in the last decade of the eighteenth century. In a second exploring expedition to the Niger and the Gambia, Mungo Park was drowned, in 1806.

Sounding the Ocean of Air. By A. Lawrence Rotch. Illustrated. S.P.C.K. .. .. .. 2s. 6d.
The kite and balloon researches carried out by Mr. Rotch, director of the Blue Hill Meteorological Observatory, in the United States, have long been famous in the history of meteorology. The progress of aeronautics makes it essential that the movements of the upper air, now so little understood, should be fully investigated, and no better introduction to the study could be obtained than that given in this book.

Master Mariners. By J. R. Spears. 256 pages. Williams and Norgate .. .. .. 1s.
This story begins with the enterprise of Niku, King of Egypt, who, in the 6th century B.C., sent out a fleet manned by Phœnicians to sail round Africa. It follows the adventures of the mariners of the Dark Ages, of those who opened up the Atlantic, of Columbus and America, of Dutch and English interests conflicting at sea, of the days of Nelson, of Captain Cook, and of later mariners and the advantages they have won for commerce and civilisation.

In the Antarctic. By Sir Ernest Shackleton. 255 pages. Illustrated. Heinemann .. 1s. 6d.
A short account of the intrepid explorer's British Antarctic expedition of 1907-1909, adapted from his larger work, "The Heart of the Antarctic." A stirring tale, with good photographs.

Discovery of the Source of the Nile. By John H. Speke. 477 pages. Dent .. .. 1s. net
Published in 1863, in the author's thirty-seventh year, this "Journal of the Discovery of the Source of the Nile" gives a vast mass of facts about the interior of Africa, and its peoples, animals and plants, and is very readable. Though Speke's conclusions were doubted at the time, they have been proved correct.

The Glaciers of the Alps. By John Tyndall. 270 pages. Dent. .. .. 1s. net
Professor Tyndall's vivid descriptions of the Alps and of mountaineering are attractive not only because of their scientific value, but also for their interest in scenery and in climbing.

Modern Meteorology. By Frank Waldo. 460 pages. Illustrated. Walter Scott .. .. 3s. 6d.
An outline of the growth of the science of the weather, well worth bringing up to date in view of the considerable advances made by meteorologists since the book was written, in 1893.

Travels on the Amazon and Rio Negro. By Alfred Russel Wallace. 363 pages. Ill. Ward, Lock. 2s.
Dr. Russel Wallace spent the four years 1848 to 1852 on the Amazon, being attracted thereto by Edwards' "Travels on the Amazon." He has here recorded his experiences and observations of the native tribes, and also on the climate, geology, and natural history of the region.

The Wonders of Asiatic Exploration. By Archibald Williams. 159 pages. Illustrated. Seeley 2s.
Deals brightly with mid-Asia, Lhasa, Manchuria, the Pamirs, the East Indian archipelago, and New Guinea. Good photographs.

Lost England. By Beckles Willson. 192 pages. Illustrated. Hodder and Stoughton .. 1s.
A suggestive and interesting description of our submerged coasts, giving the dates and circumstances of the loss of many hundreds of square miles of English territory to the sea. Mr. Willson relates how no fewer than thirty-four towns and villages have been wiped out by erosion within the modern period. Contains, in a small compass, much to interest.

Cloud Studies. By Arthur W. Clayden. 184 pages. Illustrated. Murray .. .. .. 12s.
Intended primarily for students of weather-lore and artists, but interesting to all lovers of Nature. Explains the details of cloud structure and describes and depicts typical varieties of cloud forms. Aims at introducing a greater exactness of language in description. Has a chapter on cloud photography.

Climate. By Robert de Courcy Ward. 372 pages. Illustrated. Murray .. .. .. 6s. net
A broad treatment of the question of climate, which, while not competing with meteorological textbooks, conveys special information in an interesting way, so that the book can be read by an intelligent person who has had no special training in meteorology.

River Development. By I. C. Russell. 327 pages. Illustrated. Murray .. .. 6s. net
An admirable study of rivers, illustrated generally by the rivers of North America. The book deals with the disintegration and decay of rocks; laws governing streams; and the making of river deposits.

The Forms of Water in Clouds and Rivers, Ice and Glaciers. By John Tyndall. 192 pages. Illustrated. Kegan Paul .. .. .. 5s.
A brilliant and well-known work. Sets out from the waves of heat that produce the vapour of the atmosphere; deals with tropical rains; the condensation by mountains; the architecture of snow and ice, and the formation and motion of glaciers. The greater part of the book deals with the glaciers of Switzerland.

Earthquakes and other Earth Movements. By John Milne. 361 pages. Illustrated. Kegan Paul. 5s.
Professor Milne is the founder of the science of earthquakes, and the inventor of the instrument for recording earth movements. His work is written in a clear and authoritative manner, and is not too difficult for the general reader.

The Earth: its Shape, Size, Weight, and Spin. By J. H. Poynting. 138 pages. Illustrated. Cambridge University Press .. .. 1s. net
Professor Poynting here explains, simply and without mathematical detail, how the shape and size of the earth have been determined, how its mass has been measured, and how we know that it rotates so as to be an almost perfect time-keeper. He also gives some account of the tidal action which reduces the earth's spin.

The Atmosphere. By A. J. Berry. 146 pages. Illustrated. Cambridge University Press. 1s. net
The history of the discovery of the properties of the constituents of the air is here told in an interesting way. The author has restricted himself to chemical and physical phenomena, and has omitted meteorology. The composition of the atmosphere at different heights is discussed, and also the probable atmospheres of earlier periods. The book is quite up to date, and includes reference to atmospheric radio-activity.

The Atmosphere. By E. J. Houston. 326 pages. Illustrated. Chambers .. .. 3s. 6d.
The book tells of the height and composition of the atmosphere, of sound-waves and echoes, of climate and weather-prediction, of the various kinds of storms, and of heat and light as far as they are involved in the science of the air.

In Northern Mists. By Fridtjof Nansen. Two vols. Illustrated. Heinemann .. .. 30s. net
These volumes show the great Arctic explorer exploring, by his fireside, in later life. The knowledge of the North was gathered by vast labour in vanished times, and is only now becoming realised. Dr. Nansen promised to write a book on the history of Arctic voyages. As he studied the subject he found much unexpected material, and the task grew on him, till here are eight hundred pages, presented in sumptuous form—pages made fascinating by fancy and legend and heroism and truth, and only the year 1500, or thereabouts, is reached, with the dawn of the idea that there may be a way by the North to India. No doubt the study of comparatively modern voyaging will be continued, but here is rich treasure-trove found before that voyaging began.

Volcanoes and Earthquakes. By E. J. Houston. 325 pages. Illustrated. Chambers. 3s. 6d.
An account of some of the most memorable volcanic eruptions and earthquake shocks, from the destruction of Pompeii to the destruction of San Francisco. Descriptions are given of the best-known groups of volcanoes. There are chapters, too, on submarine volcanoes, and the extinct volcanoes of the moon. A popular treatment of the subject.

The Origin of Earthquakes. By C. Davison. 141 pages. Illustrated. Cambridge Univ. Press. 1s. net
This book considers the origin of different classes of earthquakes, and describes fully one or two examples of each class. The growth of "faults" is discussed; then the origin of simple earthquakes; twin earthquakes; complex earthquakes; fore-shocks; after-shocks; and, finally, sympathetic earthquakes.

Climatic Control. By L. C. W. Bonacina. 167 pages. Illustrated. Black .. .. 2s.
A simple discussion in textbook form of the general principles of climatology, showing how vegetation and other features of the landscape are controlled by climatic influences, and how such influences modify the life of man and his occupations. One of the objects of the writer is to induce the student to observe the climate on his own account, and form his own theories.

The Physics of Earthquake Phenomena. By C. G. Knott. 295 pages. Illus. Clarendon Press. 14s. net
The author, who has been Professor of Physics in the Imperial University of Japan, has had special facilities for studying earthquakes, and adds personal investigation to a very complete knowledge of the literature of the subject. A thoughtful book for advanced students.

Physiography. By A. L. Arey and others. 450 pages. Illustrated. Harrap .. .. 4s. 6d.
An excellent school-book, with many photographs, diagrams, and maps. The science of physiography comes from America, as this book does. Each chapter is followed by questions so devised that they cannot be answered by quoting the text. This book, like those of Suess or Salisbury, may be read for mere pleasure.

Physiography. By Thomas Henry Huxley. Illustrated. Macmillan .. .. 4s. 6d.
An introduction to the study of Nature, by a master-hand. Deals principally with the forces at work in a great river basin, setting out from the commonest and best-known phenomena, such as clouds and rain, dew and ice, and going on to the study of living matter, the movements of the earth, the sun, and gravitation. A standard scientific exposition, recently revised in the light of the latest researches.

The Depths of the Ocean. By Sir John Murray and Dr. Johan Hjort. 821 pages. Illustrated. Macmillan .. .. 28s. net
A general account of the new science of the deep seas, based largely upon a recent voyage of exploration in the North Atlantic. Contains a sketch of the investigations of the "Challenger" and other expeditions; describes the depths and deposits of the ocean; its plant life; the deep-sea fishes, and general biology.

The Aurora Borealis. By Alfred Angot. 264 pages. Illustrated. Kegan Paul .. .. 5s.
A sketch of the history of the subject, followed by an account of the forms of the Polar aurora; a description of its physical characters, and its extent, position, and frequency. The concluding chapters are concerned with the connection between the aurora and weather conditions, and with the magnetism of the earth, and the theories of its origin. Written in a clear way.

The Alps in Nature and History. By W. A. B. Coolidge. 440 pages. Illus. Methuen. 7s. 6d. net
Offers the reader an account of the most interesting features presented by the Alps, based on the personal experience of over forty years' wanderings through every district of the great chain. The mountains are looked at from the physical side first; then the human history of the famous heights is related.

Science of the Sea. Prepared by the "Challenger" Society. 452 pages. Illustrated. Murray. 6s. net
An excellent handbook of practical oceanography for travellers, sailors, and yachtsmen, and admirable for the general reader. Gives the results of modern discoveries regarding the life and conditions of the deep seas—a new science established during the "Challenger" expedition The various chapters are written by men of high authority.

Forecasting Weather. By W. N. Shaw. 380 pages. Illustrated. Constable .. .. 12s. 6d.
The result of eleven years' experience in weather forecasting, by the Director of the British Meteorological Office. Explains the way in which synoptic charts are made, and how they are used in foretelling weather conditions. Chapters on gales and storm warnings, land and sea fogs, night frosts, colliery warnings, and forecasts for airmen. A standard work.

The Discoveries in Crete. By Ronald M. Burrows. 244 pages. Illustrated. Murray .. 5s. net
Deals in an attractive and popular way with the digging up of the buried civilisation of the Mediterranean sea-kings, and the bearing of the discoveries on the history of civilised man. Aims at giving a picture of Cretan culture as a whole, and at presenting it in a manner that will make it alive and real.

PHYSICS AND KINDRED SUBJECTS.

Textbook of the Principles of Physics. By A. Daniell. 782 pages. Illustrated. Macmillan. 17s.
This very comprehensive work, by a barrister who is one of the most widely learned students of our generation, deals systematically with the entire science. It is highly condensed, and is designed for the advanced learner rather than for the beginner. There is a good bibliography. Among its subjects are: The properties of matter, the problems of time and space, the nature of work and energy, and the sciences of heat, light, electricity, and magnetism.

The New Chemistry. By Josiah Parsons Cooke. 400 pages. Kegan Paul .. .. .. 5s.
Originally delivered as Lowell lectures in 1872, the contents of this book were revised in 1884, and at that date formed a succinct and interesting summary of chemistry in its latest phases.

The Evolution of Forces. By Gustave le Bon. 388 pages. Illustrated. Kegan Paul .. 5s.
Dr. Le Bon illustrates in this book his theory that the atom is a great reservoir of energy, and the source of most of the forces of the universe. The further study of radiations, phosphorescence and the Hertzian waves is tending rapidly to the acceptance of this theory.

Principles of Electricity. By N. R. Campbell. 91 pages. Jack .. .. 6d.
Designed for the general reader who has no previous knowledge of the subject, yet requiring close attention and careful thought. The book deals with the laws and theory of electrostatics; electrostatic measurements; electro-magnetism; Faraday's theory, and Maxwell's theory.

Experimental Researches in Electricity. By Michael Faraday. Dent.. .. .. .. 1s.
This volume includes Faraday's most famous lectures on electricity, as well as a sympathetic account of the man by Professor Tyndall.

Introduction to Physical Science. By A. P. Gage. 359 pages. Illustrated. Ginn .. 4s. 6d.
A school-book on elementary physics, including properties of matter, dynamics, heat, sound, light, electricity, etc.

Elementary Chemistry. By F. B. Emery. 629 pages. Illustrated. Williams and Norgate .. 8s. 6d. net
An excellent introduction to the subject, of the school-book type. Deserves special mention as a laboratory manual, and as giving due place to metallurgy.

The Chemical History of a Candle. By Michael Faraday. 113 pages. Illus. Hutchinson. 10d. net
Famous popular lectures by the great chemist. With introduction by Sir W. Crookes.

The Wonders of Modern Electricity. By C. R. Gibson. 161 pages. Illustrated. Seeley 2s.
An admirable popular account of electricity and of the part which it plays in modern life. The sections on telegraphy and wireless telegraphy are specially interesting.

Scientific Ideas of Today. By C. R. Gibson. 344 pages. Illustrated. Seeley .. .. 5s. net
A very popular yet truly scientific exposition of subjects such as atoms, electricity, ether, magnetism, light, colour, radium, gravitation, etc. As readable as a really good story.

The Romance of Modern Electricity. By Charles R. Gibson. 345 pages. Illustrated. Seeley 5s.
Describes in simple language, suited to young readers, the story of electricity; how it came to be known; its relation to magnetism; the various ways in which it is used, and its great value to life in so many different channels.

Electricity. By Gisbert Kapp. 253 pages. Williams and Norgate .. .. 1s.
The Professor of Electrical Engineering at Birmingham University here describes the force

and action of electricity, the methods of electrification, and the distribution of electricity under the many aspects in which our knowledge and use of the force today present themselves.

Electricity of Today. By C. R. Gibson. 346 pages. Illustrated. Seeley .. .. .. 5s. net
A book similar to the same author's "Wonders of Modern Electricity," but covering a wider ground. Deals with electric traction, lighting, electro-chemistry, telephones, telegraphy, electrical measurements, etc. Very popular.

Modern Organic Chemistry. By C. A. Keane. 503 pages. Illustrated. Scott .. .. 6s.
An attempt to lay down stepping-stones to the general principles and technicalities of organic chemistry, and to illustrate the methods and applications of the science by simple and typical examples.

Physical Properties of Gases. By A. L. Kimball. 238 pages. Illustrated. Heinemann 5s.
A popular introduction to the subject, from Johns Hopkins University, in the U.S.A. Not a school-book. Deals with pressure, buoyancy, elasticity, expansion, high vacua, diffusion, thermo-dynamics, radiant matter, etc.

The Radio-Active Substances, their Properties and Behaviour. By Walter Makower. 301 pages. Illustrated. Kegan Paul .. .. 5s.
One of the most recent additions to the International Scientific Series, dealing with some of the latest phases of scientific investigation. It attempts to present the chief phenomena and theories relative to radio-activity, and to serve as an introduction to the subject for students of both physics and chemistry. The subject is treated simply, and, as far as possible, without mathematical analysis.

Coal and What We Get From It. By Raphael Meldola. Illustrated. S.P.C.K. .. .. .. 2s. 6d.
To the reader who is unaware what a variety of useful products are obtained from coal by modern industry, this book, by the Professor of Chemistry at the Finsbury Technical College, will come as an astonishing revelation. Specially interesting are the processes by which brilliant dyes are obtained.

Chemistry. By Raphael Meldola. 247 pages. Williams and Norgate .. .. .. 1s. net
Deals in a popular way with the principles of chemical science and its manifold relations to other branches of knowledge. The work is comprehensive and modern.

The Chemical Elements. By M. M. P. Muir. 196 pages. Illustrated. Hodder and Stoughton 1s. net
A good popular book on the elementary and fundamental principles of chemistry, dealing with the character of chemical change; the classification of material things; the compositions and properties of carbon compounds; the atom and the molecule; molecular architecture, and other subjects.

Alchemy and the Beginnings of Chemistry. By M. M. P. Muir. 185 pages Illustrated. Hodder and Stoughton .. .. 1s. net
This little work is of interest in more ways than one. It gives a history of quasi-scientific thought, on the subject of material changes, from the days of ancient Greece down to the eighteenth century. It affords "a pregnant example of the contrast between the scientific and the emotional methods of regarding nature, and admirably illustrates the differences between well-grounded, suggestive hypotheses and baseless speculations." It gives a philosophical explanation of alchemy, showing that these fancies appealed to the deep-seated want of human beings—viz., the necessity for the realisation of order in the universe. And, finally, it traces very clearly the genesis of the modern science of chemistry.

The Wanderings of Atoms. By M. M. P. Muir. 192 pages. Hodder and Stoughton .. 1s. net
An introduction to the study of the atom and the molecule, especially those of carbon and its various compounds; intended to assist both the man who desires to follow the recent developments of chemical science and the manufacturer in any of the newest branches of the chemical trades. To the latter especially the knowledge here presented, in easily available form, is an essential factor towards success.

The Story of Electricity. By John Munro. 199 pages. Illustrated. Hodder and Stoughton.. 1s. net
An excellent popular introduction to electrical science and the practical uses of electricity.

Spinning Tops. By John Perry. Illustrated. S.P.C.K. 2s. 6d.
A vivid introduction to the study of the principles of rotation, which govern equally the movements of the solar system, the gyrostat which steadies the torpedo, and the child's spinning-top.

The Wonders of Modern Chemistry. By J. C. Philip. 165 pages. Illustrated. Seeley .. 2s.
A popular and up-to-date account of the chemical elements, metals, acids and alkalis, natural waters, combustion, flame, etc.

Radiation. By P. Phillips. 91 pages. Illustrated. Jack .. .. 6d.
The radiation of energy, as in light, heat, and the Hertzian waves which are utilised in wireless telegraphy, simply but scientifically described. Radio-activity, such as that of radium, is excluded from this work. An excellent popular handbook, dealing with all the mysteries of waves in the ether, including the newly discovered fact of light-pressure.

The New Physics and its Evolution. By Lucien Poincaré. 344 pages. Kegan Paul .. 5s.
A very valuable review of the results at which physicists have been arriving during the last ten years or so. The author tries to show how the ideas prevailing today have been formed by tracing their evolution and transformations. Questions that remain in a confused state are put on one side. M. Poincaré keeps a cool head in the midst of many enthusiasms.

Organic Chemistry. By Victor von Richter. English translation by E. F. Smith. Two vols. Illustrated. Kegan Paul .. .. 30s.
Highly technical, but a standard work. A book not to be read, but to be consulted.

The Pressure of Light. By J. H. Poynting. Illustrated. S.P.C.K. .. .. .. 2s.
An interesting monograph, by the Professor of Physics at Birmingham, on the recently

discovered *pressure* which is exercised by light. Probably this pressure, which was hitherto entirely unsuspected, will greatly alter scientific views with regard to the propagation of light.

The Theory of Sound. By Baron Rayleigh. Two vols. Illustrated. Macmillan .. 24s. net
A highly technical and mathematical study of acoustics, suitable only for advanced students.

The Mechanics of Daily Life. By V. P. Sells. 176 pages. Illustrated. Methuen .. 2s. 6d.
An elementary manual, not on the mechanics of *life*, but on elementary mechanics; e.g., the lever, pulley, screw, pump, etc. Has the advantage that it does not use mathematics.

Matter and Energy. By Frederick Soddy. 253 pages. Williams and Norgate .. .. .. 1s.
This little book, by the lecturer in physical chemistry and radio-activity of the Glasgow University, deals in a clear and simple way with the recent discoveries which have united the sciences of physics, chemistry, and electricity. The chapter on radio-activity is of special interest, the writer being an eminent authority.

Wireless Telegraphy. By A. T. Story. 225 pages. Illustrated. Hodder and Stoughton.. 1s. net
An admirable popular introduction to this subject, dealing not only with the Marconi but also with other rival systems, and entering into the historical, electrical, mechanical, and practical aspects of the new method of communication. The book is quite recent, dealing with events and inventions of 1912.

Introduction to Mathematics. By A. N. Whitehead. 250 pages. Williams and Norgate .. 1s.
A popular introduction to various branches of mathematics, including dynamics, conic sections, trigonometry, the differential calculus, etc. To take advantage of this book the reader needs no advanced knowledge.

The Atomic Theory. By A. Wurtz. 344 pages. Kegan Paul .. .. 5s.
A review and discussion of the growth of the atomic theory, noting the work done by successive investigators, but written rather for the student than for the general reader.

Metallurgy. By H. Wysor. 308 pages. Illustrated. Williams and Norgate .. .. .. 12s. 6d. net
"A condensed treatise for college students and any desiring a general knowledge of the subject." Text and illustrations are alike excellent.

Popular Electricity. By W. Hibbert. 295 pages. Illustrated. Cassell .. .. 3s. 6d.
Gives a bird's-eye view of the many applications of electrical power; deals with dynamos, electric furnaces, electric lighting, and electric bells. Has chapters on telegraphy and telephony, electro-plating, wireless telegraphy, and electric motors. Finally, discusses X-rays and radium.

Inventions in the Nineteenth Century. By William H. Doolittle. 495 pages. Chambers 5s.
An admirable survey of the inventive genius of the nineteenth century and of its great achievements. Most comprehensive, embracing inventions of every kind—in agriculture, chemistry, medicine, surgery, dentistry, engineering, transportation, electricity, housing, conveying, storing, hydraulics, pneumatics, heating, ventilating, cooking, lighting, refrigerating, metallurgy, guns and ammunition, explosives, printing, typewriting, textiles, clothing, wood-working, furniture, bottling, preserving, leather, clocks, instruments of precision, music, optics, photography, safes and locks, ships, pottery, and a host of things inside and outside these subjects.

Chemistry. By Sir W. A. Tilden. 108 pages. Illustrated. Dent .. .. .. 1s. net
Attempts to explain the fundamental principles of chemistry to a reader entirely ignorant of the subject. An excellent elementary introduction by a first-rate authority.

Crystalline Structure and Chemical Constitution. By A. E. H. Tutton. 204 pages. Illustrated. Macmillan .. .. 5s. net
Presenting, in a concise manner, the author's original contributions to the problem of the relation between the form, structure, and physical properties of crystals and the chemical composition of the substances composing them.

Modern Views of Electricity. By Sir Oliver Lodge. 534 pages. Illustrated. Macmillan.. 6s.
This volume expounds the ethereal doctrine of electricity. "Crudely, one may say that as heat is a form of energy, or a mode of motion, so electricity is a form of ether or a mode of ethereal manifestation." This doctrine is developed by gradual stages, under the main headings: Electrostatics; conduction; magnetism; radiation. A clear and scientific exposition.

Chemistry in Space. By Van't Hoff. Clarendon Press .. .. 4s. 6d.
The book in which Van't Hoff "solved, to a certain extent, and for carbon compounds only, the problem as to the position of the atoms in the molecule." Ten years earlier he had introduced his theory in a pamphlet in Dutch. It was now formally set forth and argued, and since has been made the basis of organic chemistry, and has secured the Nobel Prize for originality and usefulness.

The Nature of Mathematics. By P. E. B. Jourdain. Jack .. .. 6d.
The purpose of this volume is to show how and why mathematical methods grew up. Very little attention is paid to the arithmetic, geometry, and algebra of the textbooks, but the development of mathematics is carefully traced, so as to lead up to their essential nature.

Dynamics. By Peter Guthrie Tait. 373 pages. Black .. .. 7s. 6d.
Reproduced from a contribution by the late Professor Tait to the "Encyclopædia Britannica," and extended to be a general introductory survey of the subject for students. The mathematics used are beyond the range of the general reader.

The Science of Light. By Percy Phillips. 92 pages. Illustrated. Jack .. .. 6d.
An elementary introduction to the subject, probably as simple in treatment as such a subject can possibly be.

Light and Photography. By H. Vogel and A. E. Garrett. 390 pages. Illus. Kegan Paul 12s. 6d.
An historical sketch of the discovery of photography, followed by a study of the chemical action of light, a description of lenses, plates

and films, and camera appliances. Then a discussion of the art of photography and the three-colour process leads to the latest developments of Röntgen ray and micro-photography, photo-telegraphy, and the cinematograph.

Heat for Advanced Students. By Edwin Edser. 478 pages. Diagrams. Macmillan .. 4s. 6d.
A comprehensive account of the science of heat, both from a theoretic and experimental point of view, but without the use of the higher mathematics. Intended primarily for students with an elementary knowledge of physical principles, but without the training necessary in using the more advanced textbooks.

The Recent Development of Physical Science. By W. C. D. Whetham. Illus. John Murray 5s.
This book brings together in concise form much of the new knowledge of our time, dealing with the philosophical basis of physical science, the liquefaction of gases, and the absolute zero of temperature, fusion and solidification, the problems of solution, the conduction of electricity through gases, and radio-activity.

Advanced Exercises in Practical Physics. By Arthur Schuster and Charles H. Lees. 376 pages. Illustrated. Cambridge University Press 8s.
Intended for students who have obtained an elementary knowledge of experimental work in physics and desire to become acquainted with the principles and methods of accurate measurement. Selected and typical exercises are given, with a view to encouraging accurate work.

The Autobiography of an Electron. By Charles R. Gibson. 216 pages. Illustrated. Seeley. 3s. 6d.
Believing that if the story of modern science were told in a very popular form it would interest a large public, the writer lets one of the smallest invisible particles of matter tell the tale of its existence. So simply written that intelligent children can become acquainted with the recent advances in physical science.

Recent Advances in Physical and Inorganic Chemistry. By Alfred W. Stewart. 272 pp. Longmans 7s. 6d. net
Deals with researches that have been carried out in the last twenty years. The chief aim of the author was to avoid, as far as possible, themes that have been fully dealt with in text-books, so as to attain a novelty in the subject-matter. Treats of experimental chemical geology, radio-activity, the rare earths, and the fixation of nitrogen.

The Conservation of Energy, being an Elementary Treatise on Energy and its Laws. By Balfour Stewart. 180 pages. Illus. Kegan Paul 5s.
In this book the universe is regarded as a thing composed of atoms, with some sort of medium between the atoms as the machine, and the laws of energy as the working of this machine. Treats, in simple language, of the transmutations of energy, its conservation and dissipation, and life as dependent upon the sun.

Radio-Active Substances and their Radiations. By E. Rutherford. 699 pages. Illustrated. Cambridge University Press .. .. 15s. net
The most complete and up-to-date work on the subject. Gives the new methods of counting the particles, and deals with the absorption of radiations by matter. Describes the thirty-two radio-active substances now known, and ends with a chapter on the radio-activity of the earth and atmosphere. A classic work, by a master of the subject who has made this study especially his own, and is a supreme authority.

Outlines of Physical Chemistry. By George Senter. 387 pages. Illustrated. Methuen .. 5s.
An elementary introduction to the science, but the writer assumes that the student has some knowledge of chemistry and physics. Deals in considerable detail with the branches of the subject that usually present most difficulty to the beginner, such as the theory of solutions, the principles of chemical equilibrium, and electro-motive force. Electro-chemistry is fully treated. Suitable for electrical engineers.

The Scientific Foundations of Analytical Chemistry By Wilhelm Ostwald. Translated by G. M'Gowan. 247 pages. Macmillan .. .. 6s. net
An elementary work on the art of breaking up compounds into their elements and determining their nature; deals with the newly discovered knowledge and laws that now permit the theory of analytical reactions to be formed. A standard work, by a master of modern science.

A Textbook of Inorganic Chemistry. By G. S. Newth. 724 pages. Illus. Longmans 6s. 6d.
Contains a sketch of the fundamental principles and theories upon which the science of modern chemistry is built. This is followed by a study of the four typical elements—hydrogen, oxygen, nitrogen, and carbon—and their important compounds. In the last part of the book the elements are treated in a systematic manner, according to the periodic law.

The Polariscope in the Chemical Laboratory. By George W. Rolfe. 320 pages. Illustrated. Macmillan .. .. 8s. net
The polariscope is largely used in the sugar industry, to distinguish the quality of the sugar solutions. The writer devotes much space to the methods in use in sugar manufacture, and also describes the part played by the polariscope in brewing, starch industries, and food and drug analysis. There is a chapter on the application of the polariscope in scientific research.

Chemical Research in its Bearings on National Welfare. By Emil Fischer. S.P.C.K. 1s. 6d.
An impassioned plea for pure scientific chemical research, by one of the greatest of living chemists. Fischer points out the value of the great German industries that have been built on modern chemistry, and shows how England suffered by taking a narrow view of chemistry.

The Gases of the Atmosphere: the History of their Discovery. By Sir William Ramsay. 308 pages. Illustrated. Macmillan .. .. 6s. net
Having taken a leading part in the recent discovery of the rarer elements of the common air, the author relates the interesting and instructive discovery of oxygen and nitrogen and the other gases in the atmosphere in which we live. A standard work.

Light for Students. By Edwin Edser. 579 pages. Illustrated. Macmillan .. .. 6s.
Written for those who wish to acquire an accurate and comprehensive knowledge of geometrical and physical optics. In many instances

results of recent researches are described in connection with the laws they elucidate. The mathematical investigations are rendered as simple as possible, and many illustrative experiments are described.

Physical Chemistry: its Bearings on Biology and Medicine. By Charles Philip. Arnold 7s. 6d. net
A series of chemical lectures to students of biology. Gives an outline of the modern discoveries of chemical processes which have an important relation to the processes of living tissues. Colloids and solutions and similar phenomena are clearly and accurately explained.

A Textbook of Organic Chemistry. By A. Bernthsen. Translated and revised by J. J. Sudborough. 674 pages. Blackie .. .. .. 7s. 6d.
Based on a German work, but revised and brought up to date by a well-known Welsh chemist, the book aims at laying stress upon the general principles of the science and the relationships of substances rather than being a collection of isolated facts.

Practical Microscopy. By F. S. Scales. 334 pages. Illustrated. Baillière .. .. 5s. net
A revised and extended edition of a useful book for beginners in microscopic work. Has chapters on the choice of a microscope and the accessories needed. Very good in the manipulation of the instrument, providing the practical information and advice that amateurs want.

Elementary Physical Optics. By W. E. Cross. 312 pages. Clarendon Press 3s. 6d
An attempt by a teacher to present the difficult study of light in the most practical way. The aim of the author has been to make the subject really educative instead of introducing problems that may be solved mechanically.

The New Knowledge. By Robert Kennedy Duncan. 257 pages. Illus. Hodder and Stoughton 6s. net
A popular account of the new physics and the new chemistry in their relation to the new theory of matter. Deals with the discoveries of Monsieur Curie, J. J. Thomson, Ernest Rutherford, and Frederick Soddy in a very readable and instructive way.

Inorganic Chemistry. By E. C. C. Baly. Jack 6d.
In an interesting introductory chapter Professor Baly shows how the modern conceptions of chemistry were progressively reached through the work of Dalton, Berzelius, Gay-Lussac, Boyle, and Avogadro. He then deals with formulæ and equations; elements and compounds; salts; chemical analysis and chemical reaction, and concludes with spectroscopy—a wide range, covered with a skilful simplicity.

Organic Chemistry. By J. E. Cohen. Jack 6d.
The extreme difficulty of explaining so exclusively technical a subject as organic chemistry—that branch of the science of chemistry which treats of the compounds of carbon—is surmounted in this volume probably as well as it ever can be surmounted for general study.

Elementary Mechanics. By G. Goodwill. 230 pages. Clarendon Press .. .. .. 4s. 6d.
Professor Carey, of Liverpool University, writes an introduction to this book, in which he says it recasts the order in which the subject of mechanics is presented to the student, and also widens the range of the subjects usually presented. It is based on experimental work; it introduces simple experiments which help the student to understand the fundamental notions of mechanics, and in many ways shows a most helpful originality.

A Course of Elementary Practical Physics. By H. V. S. Shorter. In two parts. Part I., Mensuration, Mechanics, Hydrostatics, 112 pages, 2s.; Part II., Heat, 216 pages, 3s. Clarendon Press.
This course of study has been in use for several years at King Edward the Seventh's School, Sheffield. The author, who is the senior science-master there, claims that it combines the advantages of the older system of giving instruction by lectures and the newer system of cultivating the spirit of intelligent inquiry on the part of the pupils. The book is especially for use by teachers and in schools.

Colour in Nature. By Marion I. Newbigin. 344 pages. Murray .. .. .. 7s. 6d.
An attempt to set forth the main known facts in regard to the pigments and colours of plants and animals. It treats of the deeper problems of the subject, but the style in which this is done is lucid and attractive. A collection of wonderful facts and incomplete theories.

Elements of the Mathematical Theory of Electricity and Magnetism. By Sir J. J. Thomson. 550 pages. Cambridge University Press .. .. 10s.
Gives an account of the fundamental principles of the modern theory of electricity and magnetism, using only simple mathematics. A work by one of the master-minds of science, but suitable for students with an acquaintance with the elementary principles of the differential calculus rather than for the general reader.

Light. By E. J. Houston. 349 pages. Illustrated. Chambers .. .. 3s. 6d.
A book for beginners, dealing with such popular subjects as reflection and refraction; looking-glasses and burning-glasses; the kaleidoscope, the microscope and the camera; eye-glasses and the human eye; lamps and incandescent lights; the X-rays; the spectrum in rainbows; lighthouses and searchlights.

Magnetism. By E. J. Houston. 525 pages. Illustrated. Chambers .. .. 3s. 6d.
In a popular way Dr. Houston tells of magnetic batteries and currents; lodestones; magnets that remember and magnets that forget; the compass and its variations; peculiarities of the earth's magnetism; and the Northern Lights. A book of common marvels attractively displayed.

Electricity and Magnetism. By James Clerk Maxwell. Two vols. Clarendon Press .. .. 32s.
One of the great books of science. It was in this book that Clerk Maxwell constructed his famous theory of electricity in which action at a distance should be replaced by action through a medium; and in it he enunciates the principles of an electro-magnetic theory of light which has formed the basis of much modern progress.

Electric Waves. By Heinrich Hertz. Translated by D. E. Jones. With a preface by Lord Kelvin. 278 pages. Illustrated. Macmillan .. 10s. net
A first-hand account of the researches on the propagation of electric action through space,

that led to the discovery of wireless telegraphy and telephony. Hertz describes how he was first led to carry out his experiments, and relates how his endeavours, long fruitless, were at last brought to a successful conclusion. The first part of the book is fairly easy; the latter part is rather abstruse.

An Introduction to Chemistry and Physics. By W. H. Perkin and B. Lean. Macmillan 3s. 6d.
Intended as a manual for students. Deals with birth of chemistry; measurements of mass, temperature, and volume; preparation of the common acids and alkalis, and formation of salts. In the second part are explained the study of fire and air; the rusting of iron; the discovery of the metals; the composition of water and properties of gases, and the transformation of matter.

Elementary Lessons in Electricity and Magnetism. By Silvanus P. Thompson. 626 pages. Illustrated. Macmillan .. .. 4s. 6d.
Deals with the progress of research up to Hertz's discovery of electric waves, and his confirmation of Clerk Maxwell's theories. Presents with clearness and brevity an elementary exposition of the leading phenomena of their relations to one another. Has a valuable chapter on dynamos and transformers, on which the author writes with authority.

Heat, a Mode of Motion. By John Tyndall. 591 pages. Illustrated. Longmans .. .. 12s.
No book written by Tyndall explains his great popularity as a lecturer and writer so clearly as this. It is graphic, experimental, instructive; but, more than that, it has the glow of enthusiasm which kindles feeling. The avowed object of it was to arouse interest as well as to impart knowledge, and this it does by tingeing all its pages with the personality of the teacher.

Natural Sources of Power. By Sir Robert Ball. 348 pages. Illustrated. Constable .. 6s. net
Water-power and methods of measuring, and application to driving of machinery. Various types of turbines and construction of water-power plants; wind-pressure and methods of measuring; the application of wind-power to industry; the construction of modern windmills and the cost of power generated by them.

Progress of Science in the Nineteenth Century. By J. Arthur Thomson. 536 pages. Chambers. 5s. net
A record of some of the great achievements of science during the nineteeth century, dealing chiefly with discoveries in relation to matter and energy, and the science of organisms and psychology, anthropology, and sociology. Like all Professor Thomson's books, the treatment is in every way excellent.

Lectures on Sound. By John Tyndall. 335 pages. Illustrated. Longmans .. .. 10s. 6d.
An attempt to render the science of sound interesting to persons who do not possess any special scientific culture. The subject is treated throughout by experiment, and Tyndall writes so vividly that the reader realises each description as an actual operation. One of the standard books on the subject, by a man who was a master of literary effect, as well as of scientific knowledge.

The Wonderful Century. By Alfred Russel Wallace. 400 pages. Charts. George Allen .. 7s. 6d. net
An appreciation of the nineteenth century—its successes and failures. Successes embrace means of travel; labour saving; conveyance of thought; fire and light and their applications; and discoveries in physics, chemistry, astronomy, geology, and physiology. The failures, in the author's view, are the neglect of phrenology; the opposition to hypnotism and psychic research; the "delusion" of vaccination; the spread of militarism and greed, and the plunder of the natural treasures of the earth.

Electrons; or, the Nature and Properties of Negative Electricity. By Sir Oliver Lodge. 245 pages. Bell .. .. 6s.
This book has developed from an address on the recent discoveries respecting the nature of electricity. It discusses the evidence that the constitution of matter is electrical in its ultimate form. Sir Oliver holds that scientific outlook is greatly changed by the new knowledge that is being gained concerning radio-activity and electrical phenomena.

The Becquerel Rays and the Properties of Radium. By Hon. R. J. Strutt. 215 pages. Illustrated. Arnold .. .. 8s. 6d.
Written with the object of giving a clear and simple account of the phenomena of radio-activity without sacrificing accuracy of statement. Intended for the general reader with little or no previous scientific knowledge. Ends with a chapter on the electrical theory of the nature of matter.

A History of the Cavendish Laboratory, Cambridge. 342 pages. Illustrated. Longmans 7s. 6d. net
A book in celebration of the twenty-fifth year of Sir J. J. Thomson's tenure of the Cavendish professorship. Gives the story of the building of the laboratory by the Duke of Devonshire, and the work done in it under Clerk-Maxwell, Lord Rayleigh, and Sir J. J. Thomson. There is no post in the world which has been held successively by three men of such supreme genius. Their experiments, ideas, and teaching have changed the foundations of some important branches of science.

The Chemistry of Fire. By M. M. P. Muir. 163 pages. Illustrated. Methuen .. 2s. 6d.
Setting forth in a simple way the chief principles of chemistry, by the study of the burning of a candle. The close connection between the science of chemistry and the occurrences of everyday life is emphasised.

The Chemistry of the Radio-Elements. By Frederick Soddy. 92 pages. Longmans .. 2s. 6d. net
A summarised account of recent progress on the main lines of research in radio-activity. Gives a general description of radio-activity, and the periods of average life of radio-active substances, with a classification of the new kind of elements. Further, it deals in detail with the latest researches on radium, uranium, thorium, and similar forms of matter.

The Principles of Chemistry. By D. Mendeléeff. Two vols. Illustrated. Longmans 32s.
One of the great classics of science, by the Newton of modern chemistry, discoverer of the

periodic law in the relation of the elements of the universe. It was in writing this book, which aims at presenting the generalisations rather than the facts of chemical research, that the famous Russian man of science made his great discovery. Begins with simple facts, and ends in magnificent generalisation.

Colour Sense. By Grant Allen. 282 pages. Kegan Paul .. .. 10s. 6d.
An attempt to prove that the colour-sense of mankind dates back to the earliest appearance of our race upon earth, and that it is partly connected with sexual selection. Discusses the colour-sense in insects, birds, and mammals, and its relation to the flowers and fruits which animals feed on. Concludes with chapters on the artistic value of colours.

Fragments of Science. By John Tyndall. Two vols. Longmans .. .. .. 16s.
The first volume of this celebrated series of scientific essays deals with the laws and phenomena of matter; the second volume touches on questions in which the problems of matter are interlaced with those of mind. Brilliant and clear in style, covers a wide field of knowledge, and is rationalistic yet sympathetic in discussing the clash of scientific ideas with religious dogmas. Professor Tyndall's "New Fragments," a later companion volume, is published by Longmans at 10s. 6d. net.

Electrons; or, the Nature and Properties of Negative Electricity. By Sir Oliver Lodge. 245 pages. Bell. 6s.
A discourse on recent progress towards knowledge of the nature of electricity, especially as concerns atomic structure. The greater part of the text is written in the plain, energetic English characteristic of the author, but a few mathematical equations are introduced.

Textbook on Sound. By Edwin H. Barton. 687 pages. Illustrated. Macmillan .. 10s. net
A book distinctively for students. It embraces both the experimental and theoretical aspects of sound. The various typical musical instruments are discussed from the view-point of the physicist. The book covers the whole subject for examination purposes, and by its illustrations and exercises ranks as a useful classbook.

The Electron Theory. By E. E. Fournier d'Albe. 327 pages. Illustrations. Longmans .. 5s. net
A popular introduction to the new theory of electricity and magnetism, largely based on Johnstone Stoney's views. A suggestive and stimulating speculation in regard to the ultimate problems of matter and force, by a writer with original ideas.

Elements and Electrons. By Sir William Ramsay. 172 pages. Harper .. .. .. 2s. 6d. net
A brief first-hand account of the new theory of the transformation of matter, by the boldest and most successful of experimenters. Describes the modern advances in the study of matter, and discusses the evolution of the atom, and the changing of one element into another.

Radio-Activity and Geology. By J. Joly. 287 pages. Illustrated. Constable .. .. 7s. 6d. net
An account of the influence of radium and other forms of radio-active energy on the history of the earth. Shows how Lord Kelvin's estimate of twenty million years for the age of the earth has been upset by modern discoveries. An interesting and clearly written account of the present state of the problem.

Light, Visible and Invisible. By Silvanus P. Thompson. 294 pages. Illustrated. Macmillan. 6s. net
A brilliant, simply worded, and scientific account of ordinary light, the invisible part of sunlight, and cathode rays, and Röntgen rays. The standard book on the subject of a popular sort, written by a first-rate man of science who has the art of explaining difficult things in a graceful and easy way.

The Corpuscular Theory of Matter. By Sir J. J. Thomson. 172 pages. Constable .. 7s. 6d.
Describes the author's famous experiments that resulted in the breaking up of the atom into electrons or corpuscles, consisting of charges of negative electricity. One of the master-works of modern science, originally delivered in the form of lectures at the Royal Institution. Difficult in places for the general reader, but worth tackling, even by him.

Studies in Radio-Activity. By W. H. Bragg. 196 pages. Illustrated. Macmillan .. 5s. net
An account at first-hand of some very interesting experiments with X-rays and similar rays emitted by radium. Professor Bragg contends that these rays are not waves or pulses of electro-magnetic energy, but minute particles of matter. This theory, however, has just been overthrown by the discovery that X-rays are very small electric waves.

Liquid Air, Oxygen, and Nitrogen. By Georges Claude. Translated by H. E. P. Cottrell. 418 pages. Illustrated. Churchill .. 18s. net
Gives a sketch of the attempts to reduce gases to a liquid state, and the various commercial processes for the liquefaction of air. Discusses the properties of liquid air, and the part played by Dewar in inventing the means of storing it. A practical work on the subject.

LIFE

Embracing Biology, Evolution, Heredity, and Microscopic Study.

Evolution. By Patrick Geddes and J. A. Thomson. 248 pages. Williams and Norgate .. 1s. net
These two authors have collaborated before, as in their famous "Evolution of Sex." Here they give an excellent summary of the principal facts and theories relating to organic evolution.

The Biology of the Seasons. By J. Arthur Thomson. 384 pages. Illustrated. Melrose .. 10s. 6d. net
Intended for all who enjoy the pageant of the year and the drama of the seasons, and who see something of the evolutionary flow of things in the annual spectacle. The aim of the book is to get at the gist or inwardness of the yearly drama without going too minutely into the details of the successive scenes. Vivid, interesting, and thought-providing.

The Evolution of Sex. By Patrick Geddes and J. Arthur Thomson. 342 pages. Illustrated. Walter Scott .. .. 6s.
A famous book, not to be overlooked by any student of this difficult problem. Its central

thesis is "to present an outline of the main processes for the continuance of organic life," and "to point the way towards the interpretation of these processes in those ultimate biological terms which physiologists are already reaching as regards the functions of individual life—those are the constructive and destructive changes of living matter of protoplasm."

Heredity. By J. Arthur Thomson. 621 pages Illustrated. Murray .. .. .. 9s. net
An up-to-date and comprehensive introduction to the study of heredity, followed by a remarkable bibliography and a subject index for enabling the student to pursue inquiry further on particular points. Professor Thomson is admittedly a follower of Weismann. His book gives prominence to conclusions reached first by the microscopic study of the germ-cells; secondly by the application of statistical methods, and third through experiment.

Darwinism and Human Life. By J. Arthur Thomson. 245 pages. Melrose .. .. .. 5s. net
Darwinism, and an estimate of the present position of the Darwinian theory in relation to the work of Mendel and De Vries. An endeavour is also made to suggest how Darwinism touches everyday life, in farm and garden, in city and empire. Written in a clear and attractive way, and delivered in the form of lectures in South Africa in 1909.

The Wonders of Life. By Ernst Haeckel. English translation by J. McCabe. 160 pages. Watts. 1s. net
A "popular study of biological philosophy." Learned, clear, and suggestive, marked by a tone of aggressive agnosticism, and represents a mode of thought which is rather of yesterday than of today. The book has four main sections, dealing with the knowledge of life, the nature of life, the functions of life, and the history of life. The fourth contains Haeckel's exposition of his "monism."

The History of Creation. By Ernst Haeckel. Revised by Sir E. Ray Lankester. Two vols. Illustrated. Kegan Paul .. .. 18s. net
The object of this important book is to describe the development of the earth and its inhabitants by the action of natural forces. A popular exposition of the doctrine of evolution in general, and that of Darwin, Goethe, and Lamarck in particular. Gives a sketch of the development of life, and the migration and distribution of the human species.

The Evolution of Man. A Popular Scientific Study. By Ernst Haeckel. Translated by J. McCabe. Two vols. Illustrated. Watts .. 12s. 6d. net.
An attempt to trace the series of man's ancestors, and to indicate the several stages in animal organisation which led up to his appearance. Largely based on the study of embryos. A bold attack on an obscure and difficult problem. There is still much dispute as to the line of human ascent from the lower animals.

The Principles of Biology. By Herbert Spencer. 1366 pages. Williams and Norgate .. 36s.
The aim of this work is to set forth the general truths of the study of life as illustrative of the laws of evolution; it also shows how a knowledge of these laws helps to illumine and interpret the facts of biology. In regard to the manner in which life evolved, Spencer holds to Darwin's theory of natural selection, but allows something to the inheritance of acquired character.

Various Fragments. By Herbert Spencer. 156 pages. Williams and Norgate .. .. .. 4s.
Valuable for the articles on social and ethical evolution, that give the last ideas on life of a great thinker. Some of the papers are criticisms of the work of other sociologists.

The Effects of Cross and Self Fertilisation in the Vegetable Kingdom. By Charles Darwin. 487 pages. Murray .. .. .. 9s.
Most flowers are constructed so as to be fertilised by pollen from another flower. Self-fertilisation leads more easily to production of seeds; cross-fertilisation helps a species of plant to take advantage of slight changes in the conditions of life, making it more adaptable. Darwin found also in his experiments that cross-fertisation increased the vigour, height, and fertility of plants.

The Origin of Species by Means of Natural Selection. By Charles Darwin. 458 pages. Murray 1s.
The work that changed the principles and aims of biology and revolutionised the thoughts of man. Setting out from the variation of animals under domestication, Darwin seeks for some natural means of controlling the building up of species from gradually formed varieties. He finds this control in the selective process of the struggle for existence, leading to the survival and multiplication of the fittest.

Darwinism. By Alfred Russel Wallace. 510 pages. Illustrated. Macmillan .. .. 7s. 6d.
This exposition of the theory of natural selection with some of its applications has a special value as being by Darwin's co-discoverer of the principle. The book treats of the struggle for existence; variability in a state of nature and in domesticated animals and plants; natural selection; cross-breeding and hybridisation; origin and uses of colour in animals; mimicry; sexual characteristics; colours of plants; distribution of organisms; geological evidences of evolution; problems of variation and heredity, etc. Of value historically, but needs to be read in combination with more recent works.

Island Life. By Alfred Russel Wallace. 584 pages. Illustrated. Macmillan .. .. 7s. 6d. net
A most delightful and masterly study of the phenomena and cause of insular floras and faunas, with a revision and attempted solution of the problem of geological climates. The author is convinced that the distribution of the various species and groups of living things over the earth's surface, and their aggregation in definite assemblages in certain areas, is the direct result and outcome of a complex set of causes, biological and physical. These causes are clearly and convincingly expounded.

The World of Life. By Alfred Russel Wallace. 408 pages. Illustrated. Chapman and Hall. 12s. 6d.
A self-made summary of the life-work, in the realm of scientific thought, of one of the greatest of the pioneers of evolution, carrying on towards something like completion the work of Darwin. Wallace regards the age-long development of life as stages in the growth towards man, the crowning product of the process.

Germ Life: Bacteria. By H. W. Conn. 212 pages. Illustrated. Hodder and Stoughton .. 1s. net
Recognising that bacteria are generally regarded only as agents of disease, the author has here given a wider and more balanced view of the subject. He shows that these organisms "are to be regarded not primarily in the light of enemies, but as friends." The subject is ably treated in popular language.

Evolution. By E. S. Goodrich. 108 pages. Illustrated. Jack .. .. 6d.
An examination, based on modern research, of the factors which have moulded the evolution of living organisms. This is a subject which, from the days of Lamarck and of Darwin, has produced enormous controversy. But it is now less controversial, as it has become more experimental; and the main conclusions of modern biology will be found well summed up here.

How to Use the Microscope. By Rev. C. A. Hall. 88 pages. Illustrated. Black .. 1s. 6d.
This is a delightful and thoroughly practical little book for Nature lovers who desire to become acquainted with the microscope. It explains how a dissecting microscope may be extemporised, and how the author made a compound instrument with very little expense. Elaborate explanations are avoided; just enough is told for the beginner's guidance.

Nature Study and Life. By Clifton H. Hodge. 514 pages. Illustrated. Ginn .. .. 7s.
This book is intended to meet and encourage the love of children for outdoor life. It begins with animal life and insects, after which come studies of plants and discussions of gardens. A great deal of scientific information is given in a manner very stimulating to outdoor practice and research.

Life and Matter. By Sir Oliver Lodge. 200 pages. Williams and Norgate .. .. .. 2s. 6d. net.
"An exposition of part of the philosophy of science, with special references to the influence of Professor Haeckel." An able essay, antagonistic to materialism.

The Prolongation of Life. By E. Metchnikoff. 343 pages. Illustrated. Heinemann .. .. 6s. net
This work is a sequel to the "The Nature of Man" by the same author, who believes that science may greatly prolong the lives of individuals, and thereby solve some difficult social questions. An extremely optimistic essay by a great experimentalist.

Outlines of Biology. By P. Chalmers Mitchell. 348 pages. Illustrated. Methuen .. 6s. net
This book is an invaluable manual for examination students. It has been specially revised by Dr. G. P. Mudge to meet the requirements of the conjoint examining board of the Royal Colleges of Physicians and Surgeons of England.

Heredity. By James Watson. 90 pages. Illustrated. Jack .. .. 6d.
The Lecturer in Agriculture of Edinburgh University summarises the main facts of heredity, with special reference to variation, causes of variation, Mendelism, the problems of the practical breeder, and eugenics. The author is an ardent eugenist, but expects more results in that direction from popular education than from legislation.

Origin and Nature of Life. By Benjamin Moore. 256 pages. Williams and Norgate .. 1s. net
This book, by the Professor of Bio-Chemistry in the Liverpool University, traces, as thoroughly as modern knowledge allows, the relation of the phenomena of life with chemical and non-vital processes. "Life probably arose as a result of the operation of causes which may still be at work today, causing life to arise afresh."

The Universe. By F. A. Pouchet. 576 pages. Illustrated. Blackie .. .. .. 7s. 6d.
This handsomely illustrated volume on "the infinitely great and the infinitely little" is an admirable popular treasury of facts relating to animals and plants of all kinds and in all parts of the world. A really sound book to give to a boy or a girl, or to read oneself.

The Laws of Heredity. By G. Archdall Reid. 540 pages. Methuen .. .. .. 21s. net
A work which deals very widely with the problems of inheritance, including studies of Lamarck's doctrine, the Mendelian theory, immunity, alcoholism, physical deterioration, insanity, etc. Dr. Reid is far from being orthodox, but is always interesting.

The Germ-Plasm: a Theory of Heredity. By A. Weismann. 477 pages. Illustrated. Scott. 6s.
A translation, by Dr. W. Newton Parker, of the University College of South Wales, of a book which has been built into the very structure of all philosophical thought with regard to heredity during the last twenty years, and which no faithful student of the subject can omit to read first-hand.

The Child: A Study in the Evolution of Man. By Dr. Alexander Francis Chamberlain. 405 pages. Illustrated. Scott .. .. .. 6s.
An extremely interesting book, tracing the most important phenomena of human beginnings in the individual and the race. The child is treated as a revealer of the past, and as indicating in its growth the progress of mankind. In making his investigations the author has covered a wide range of literature; indeed, the bibliography of books used fills thirty pages.

The Story of Evolution. By J. McCabe. 340 pages. Illustrated. Hutchinson .. .. 7s. 6d. net.
A popular and fascinating account of the development of the universe, from the birth of worlds, through the evolution of life, to the dawn of civilisation and the evolution of history. Learned and readable. A comprehensive and reliable summary of our knowledge up to 1912.

Variation in Animals and Plants. By H. M. Vernon. 415 pages. Kegan Paul .. .. .. 5s.
The attention given to variation in animals is much more complete in this book than that given to plants. The author has proceeded on his own lines, both as regards experiment and the formation of opinion, and the book is the more interesting as the result of personal study by one who also is a wide reader.

Evolution and the Function of Living Purposive Matter. By N. C. Macnamara. 298 pages. Illustrated. Kegan Paul .. .. .. 5s.
An endeavour to explain the evolution of and purposive functions performed by those elements of protoplasm essential for purposive, instinctive, and physical phenomena, with a view to

realising the importance of heredity in determining the personal character of individuals, and the influence of environment in modifying innate qualities.

Evolution and Disease. By J. B. Sutton. 285 pages. Illustrated. Scott .. .. .. 3s. 6d.
Disease, as well as growth, has its natural history of increase and decline, and in this book the author traces, in animals as well as in man, the normal development of the abnormal.

Manual of Bacteriology. By Robert Muir and James Ritchie. 605 pages. Illustrated. Hodder and Stoughton .. .. 10s. 6d. net
A most valuable book, comprising a systematic description of the various kinds of bacteria, and a consideration of the evidence of their relation to various diseases. There is a splendid bibliography at the end.

The Individual in the Animal Kingdom. By Julian S. Huxley. 167 pages. Illustrated. Cambridge University Press .. .. .. 1s. net
The author begins by framing a general definition of the individual, and then tries to show in what way individuality so defined manifests itself in the animal kingdom. He argues that living matter always tends to group itself into closed, independent systems with harmonious parts. Though the closure is never complete, the independence never absolute, yet systems and systems and tendency alike have real existence. The unwieldiest individual, formless and blind today, says the author, is the State.

Evolution, the Master-Key. By C. W. Saleeby. 359 pages. Harper .. .. 7s. 6d.
Writing in a clear and popular manner, Dr. Saleeby traces the principle of evolution in atoms and stars, living things, in the development of mind, and social affairs and morals. The work is largely based upon the ideas of Herbert Spencer, but is also up to date.

The Microscope. By Jabez Hogg. Illustrated. Routledge .. .. 10s. 6d.
An all-round book on the subject. It gives the history of the invention and its improvements, and deals very clearly with the practical use of the microscope and its accessories. In the second part there are useful descriptions of the commoner objects of microscopic study.

Heredity. By L. Doncaster. 160 pages. Illustrated. Cambridge University Press .. .. 1s. net
A sketch of the most important lines of study in relation to heredity that have recently been followed. The reader is taken over the most modern developments by one who regards Mendelism as established, and who is a thorough-going disciple of Professor Bateson.

Breeding and the Mendelian Discovery. By A. D. Darbishire. 282 pages. Illustrated. Cassell. 7s. 6d.
Owing to Mendel's discovery that plants and animals are made up of character units which are inherited in an orderly fashion, it is now becoming possible to reduce the breeding of special varieties to a science, as Mr. Darbishire shows. Farmers, fanciers and gardeners will be interested in this work.

The Science and Philosophy of the Organism. By Hans Driesch. Two vols. Black .. 21s.
An abstruse and somewhat involved statement of a very interesting theory of life. The author regards the life-force as a self-governing thing that evolves according to its own laws and to the circumstances in which it is placed. Dr. Driesch goes back to Aristotle for his ideas of life, but interprets these ideas in the full light of modern research.

Mendel's Principles of Heredity. By W. Bateson. 430 pages. Illustrated. Cambridge University Press .. .. 12s. net
A full and clear account of the new science of life, based on the recent rediscovery of the neglected work of the greatest of Darwin's contemporaries, the Roman Catholic abbot Mendel. Professor Bateson gives an interesting sketch of Mendel's life, and shows to what remarkable results his work is leading.

Charles Darwin and the Theory of Natural Selection. By E. B. Poulton. 232 pages. Cassell. 2s. 6d.
A concise and readable account of the strictly Darwinian view of the evolution of life, by an English professor who has done some fine work in the study of mimicry. Since, however, the book was written the rediscovery of Mendel's law has rather altered the complexion of some of the problems.

Mendelism. By R. C. Punnett. 196 pages. Illustrated. Macmillan .. .. .. 5s. net.
Published in 1905, this little book has continually been extended in size, in order to deal with the progress of the new science of heredity and breeding, until it is now three times as large as it originally was. It deserves its popularity, for it is written in a lucid and broad manner by a first-rate authority.

The Cell: Outlines of General Anatomy and Physiology. By Oscar Hertwig. Translated by M. Campbell. 384 pages. Illustrated. G. Allen. 7s. 6d. net
A standard book on the subject by the foremost European authority. Much has been done in the eighteen years since this translation of Professor Hertwig's work was published, but the book retains its value as an introductory study.

The Cell in Development and Inheritance. By Edmund B. Wilson. 504 pages. Illustrated. Macmillan .. .. 15s. net.
One of the standard works on the study of the living cell. It is for the most part written in highly technical terms, but when a reader has mastered the language he becomes acquainted at first-hand with one of the most famous pieces of research into the mysterious kingdom of life.

Problems of Life and Reproduction. By Dr. Marcus Hartog. 362 pages. Illustrated. Murray. 6s. net
A general treatise on reproduction, formed from the author's articles in various publications, supplemented and brought up to date. Among the subjects discussed are cellular pedigree, the relation of blood-formation to cell-division, the function of chromatin, the transmission of acquired characters, and mechanism and life. Dr. Hartog is a "reasonable vitalist," opposing mechanistic explanations of life.

Vestiges of Creation. By Robert Chambers. 176 pages. Routledge .. .. .. 1s.
The book which, in 1844, first brought the idea of evolution popularly before the people of the British Isles, and prepared the public mind for the writings of Darwin and the later evolutionists. The views expressed in the book were

based largely on Lamarck. Religious in tone, it attested the reign of universal comprehensive laws, as against creative fiats. Its science has now been superseded to a considerable extent by additional knowledge, but the work holds a place in the emancipation of the public from untested tradition in science.

Outlines of Bacteriology. By David Ellis. 262 pages. Illustrated. Longmans .. .. 7s. 6d. net
This book is written more particularly for the use of students of technical and agricultural bacteriology; but it will also serve as an introduction to all branches of the subject. The aim has been to demonstrate the fundamental principles underlying the technical application of bacteriology, but matters of theoretical interest have also been introduced, because the science is in a stage when theoretical extension and investigation are highly important. A remarkably comprehensive and interesting work.

Experimental Embryology. By J. W. Jenkinson. 341 pages. Illustrated. Clarendon Press. 12s. 6d.
An attempt to discover the causes that determine the form of an organism, and especially the origin of the form in the individual. Has an appreciative chapter on the work of Hans Driesch, but refuses to accept the existence of any self-governing life-force.

The Student's Handbook of Stratigraphical Geology. By A. J. Jukes-Browne. 668 pages. Illustrated. Stanford .. .. 12s. net
Consists chiefly of the description of the great stratified series of rocks that make up the mass of the earth's crust. Gives the history of the earth as revealed in the fossil life of each stratum after the earliest rocks. A first-rate handbook of the present state of the geological evidence of the evolution of life.

An Introduction to the Study of Biology. By J. W. Kirkaldy and I. M. Drummond. 259 pages. Illustrated. Clarendon Press .. .. 6s. 6d.
Intended for beginners and general readers. Presents animals and plants as living organisms with many common traits, springing from a common origin and exhibiting a similarity underlying their diverse activities of life.

Variation, Heredity, and Evolution. By Robert H. Lock. 334 pages. Illustrated. John Murray. 5s.
Deals with recent advances in the study of these aspects of biology, and forms an admirable summary of the subject, clearly and interestingly written. A reliable and readable book for students and general readers.

Microscopy. By Edmund J. Spitta. Illustrated. John Murray .. .. 12s. 6d. net
An admirable work on the construction, theory, and use of the microscope, designed to give students a complete understanding of the principles and possibilities and the effects of the instrument. A book to which microscope students may turn with confidence.

Darwinism Today. By Vernon L. Kellogg. 402 pages. Bell .. .. 7s. 6d. net
Shows the attitude of modern scientists in criticism of Darwin's theories of selection, with an account of the various other theories of the formation of species.

Essays on Evolution. By E. B. Poulton. 479 pages. Clarendon Press. .. .. .. 12s. net
A series of very readable papers by an Oxford professor of zoology. Disputes the new theory of certain writers of the Mendelian school that evolution sometimes occurs by jumps. Discusses the various theories of heredity and evolution, and includes some essays on mimicry, on which subject the writer is a well-known authority. Clearly written for the general reader, yet a most substantial contribution to the literature of science.

Darwin and After Darwin. By G. J. Romanes. Three vols. Illustrated. Longmans.. 26s. the set
An exposition of the Darwinian theory of the origin of species and the descent of man, by a famous disciple of the master, followed by an instructive discussion of the chief post-Darwinian problems prior to the recovery of Mendel's discoveries and the revival of the theory of evolution by sudden jumps. The volumes are sold separately.

Darwin and Modern Science. Edited by A. C. Seward. 595 pages. Illustrated. Cambridge University Press .. .. 18s. net
Essays in commemoration of the centenary of Darwin's birth, and the fiftieth anniversary of the publication of the "Origin of Species." A sound, brilliant, and varied review of the various branches of the science of the evolution of life, as influenced by Darwin's work. Every school of thought is fairly represented.

Essays Upon Heredity. By August Weismann. Translated by E. B. Poulton. Schonland and Shipley. Two vols. .. .. 12s. 6d.
A now famous work, written with the view to prove that characteristics acquired by parents—bodily characteristics as distinct from the characteristics of the germ-cell—are not handed on to children. On Weismann's theory, the germ-cell transmitted from generation to generation is the source of all inheritable variations from which new species arise.

Natural History of Selborne. By Gilbert White. Cheap editions
A charming record of the observation of all kinds of natural happenings in bird life, plant life, weather, etc., within a very narrow range, from year to year. The chief use of the book now is its stimulation of the spirit of observation, and its incitement to the keeping of exact records, and it is written in easy language.

The Evolution Theory. By August Weismann. Translated by J. A. and M. R. Thomson. Two vols. Arnold .. .. 32s. net
A survey of the Darwinian theory of the origin of species, and a restatement of it from the point of view of the author's own ideas. Weismann contends that no modifications of form or function that a parent or parents acquire are handed on to the children. He holds that the variations that count and that are handed on occur in the germ-cell.

The Heredity of Acquired Characters in Plants. By the Rev. G. Henslow. 107 pages. Illustrated. Murray .. .. 6s. net
The object of this book is to show that evolution, so far as plants are concerned, depends upon the inheritance of acquired characters.

It is an attack upon the Neo-Darwinism of Weismann and his followers. A good many botanists are inclined to agree with Professor Henslow's views, but students of animal life still largely hold to Weismann's theory of evolution in the germ-plasm, the body of the parent having no influence.

Design in Nature. By J. Bell Pettigrew. Three vols. Illustrated. Longmans .. .. £3 3s.
A very comprehensive work, covering wide scientific grounds—biology in its modern developments, zoology, comparative anatomy, physiology, psychology, physics, and chemistry—and illustrated by nearly two thousand figures. A valuable work of reference, by an enthusiastic student with wide experience as an observer and teacher.

The Greatest Life. By Gerald Leighton. 275 pages. Duckworth .. .. 2s. 6d. net
A consideration of the theory of immunity, based on the accepted view that life involves adaptive change in response to environment. Dr. Leighton discusses immunity from the physical, mental, moral, and emotional standpoints. A man has, he suggests, certain natural and acquired tendencies, and according to these he is good or bad. On these lines, he holds, even spiritual phenomena are capable of explanation, and he maintains that if the future evolution of man is to be in the direction of higher ethical progress, it must be by a scientific Christianity.

Essentials in Cytology. By Charles E. Walker. 139 pages. Illustrated. Constable .. 7s. 6d.
The new science of the cell, or the study of living matter in the form which carries with it inheritance and infinite power of development, is here introduced in a general way, unmixed with subsidiary subjects. A useful summary of knowledge in a restricted area.

Creative Evolution. By Henri Bergson. 425 pages. Macmillan .. .. 10s. net
The book that has been more discussed in the philosophical world than any other during the last few years. The translation is by Dr. Arthur Mitchell, of Harvard University, and Professor Bergson himself has revised the whole work carefully. His summary of his aim is that he first tries on evolutionary progress the two ready-made garments of mechanism and finality, and shows that neither fits. Next he reconstructs the main lines of evolution along which life has travelled by the side of that which has led to the human intellect. The intellect is thus brought back to its generating cause. Last, the writer tries to show how our understanding, by submitting to a certain discipline, can prepare a transcendental philosophy. This is the book on which the whole controversy respecting Bergson's philosophy is based.

Evolution and Man's Place in Nature. By Rev. H. Calderwood. 349 pages. Macmillan 10s. net
The main objects of this work are to trace the evidence of man's relation to the continuity of life on earth, and to describe the distinctive characteristics of human life. Towards the close of his survey of the facts the writer essays to reconcile the theory of evolution with religious convictions.

PLANT LIFE

Embracing Agriculture, Botany, Bacteriology, and Forestry.

The Different Forms of Flowers on Plants of the Same Species. By Charles Darwin. 352 pages. Illustrated. Murray. .. .. .. 7s. 6d.
Certain kinds of plants produce in a normal way differently formed flowers on the same stock. Inquiry into this problem leads to the question why the sexes of flowers were separated. Darwin concludes it was not for the sake of the advantages to be gained by cross fertilisation, but to reduce the number of seeds born by a plant, and save its vital energies.

The Movements and Habits of Climbing Plants. By Charles Darwin. 208 pages. Illus. Murray. 2s. 6d.
Plants do not differ from animals merely in power of movement. They display this power only when it is of some advantage to them. The capacity of revolving, on which most climbing plants depend, is inherent in an undeveloped state in almost every plant in the vegetable kingdom. Deals with twining plants, leaf-climbers, tendril-bearers, and hook and root climbers.

The Various Contrivances by which Orchids are Fertilised by Insects. By Charles Darwin. 300 pages. Illustrated. Murray. .. .. .. 2s. 6d. net
Showing that the contrivances by which orchids are fertilised are as varied and almost as perfect as any of the most beautiful adaptations in the animal kingdom. Darwin also points out that these contrivances have for their main object the fertilisation of flowers with pollen brought by insects from a distinct plant.

Insectivorous Plants. By Charles Darwin. 461 pages. Illustrated. Murray. .. 2s. 6d. net
Largely a study of the behaviour of the common sundew. Experiments on making the tentacles fall by touching them or letting water fall on them. Nature of the acid by which the plant digests insects; effects of various salts and poisons on the plant. The structure and movements of other insect-eating plants. A plant that captures crustaceans.

The Origin of Floral Structures through Insect and Other Agencies. By Rev. George Henslow. 349 pages. Illustrated. Kegan Paul 5s.
Mr. Henslow claims to suggest in this book how "the whole floral world has arisen." He refers every part of the structure of flowers to some one or more definite causes arising from environment, taken in its widest sense. In his preface he gives a useful summary of similar studies up to the date (1888) of writing.

Wayside and Woodland Trees. By Edward Step. Illustrated. Warne .. .. .. 6s. net
A pocket-guide to the British Sylva, with 127 plates reproduced from original photographs of living trees and shrubs, and 50 figures in the text of leaf, flower, and fruit. Beautifully printed and illustrated.

The Origin of Cultivated Plants. By Alphonse de Candolle. 468 pages. Kegan Paul .. 5s.
An interesting book tracing the origin of almost all plants cultivated either on a large scale for economic purposes or in orchards and kitchen-gardens. The author has endeavoured to estab-

lish the number of centuries or thousands of years during which each species has been in cultivation, and how its culture spread in different directions at successive epochs. The histories of 249 plants are investigated.

Wayside and Woodland Ferns. By Edward Step. Illustrated. Warne .. .. .. 6s. net
A pocket-guide to the British ferns, horse-tails, and club-mosses, with plates in colour of all the species, and, in addition, Nature-photographs of the growing plants. Very handy, comprehensive, and beautiful.

Agriculture. By William Somerville. 251 pages. Williams and Norgate .. .. .. 1s. net
An excellent handbook, by the Oxford Professor of Rural Economy, dealing with the formation, properties and main types of soil; the amelioration of land; the principles of manuring, including all the different kinds of fertilisers; the rotation of crops, and seed. Bibliography.

The Student's Botany. By S. H. Vines. 821 pages. Illustrated. George Allen .. .. 15s.
A conscientious review of the whole field of botany. The work is divided into four parts, dealing respectively with morphology; cells and tissues; classification, and physiology of plants. It is designed for the use of the student who is preparing for an examination, rather than for the lover of trees and plants and flowers.

The Royal Forests of England. By J. C. Cox. 372 pages. Illustrated. Methuen .. 7s. 6d. net
A historical work which will delight every lover of the English forests. A complete study of the forest courts and officers; hounds and hunting; forest trees, and of every forest separately.

Botany. By Marie C. Stopes. 94 pages. Illustrated. Jack .. .. 6d.
The modern study of plants, condensed into very small compass. Deals with morphology, anatomy, cytology, physiology, ecology, palæontology, plant breeding, pathology, systematic botany, etc. There is also a "suggested course of reading." as an educational guide.

Fungi and How to Know Them. By E. W. Swanton. 210 pages. Illustrated. Methuen .. 6s. net
This book contains descriptions of all the larger fungi—that is, of those which can be identified without the aid of a microscope. The first part deals with growth, parasitism, spore dispersal, etc. The second part contains full descriptions of the species figured in the plates. The plates, many of which are beautifully coloured, contain illustrations of nearly two hundred species. There are analytical keys to the genera, and instructions for the collector.

Wild Fruits of the Countryside. By F. E. Hulme. 212 pages. Illustrated. Hutchinson 5s. net
A beautiful pocket-manual, including 36 coloured illustrations and 25 from photographs, enabling the amateur to identify all kinds of fruits. The text is charming, and the plates are extremely beautiful.

Wayside and Woodland Blossoms. By Edward Step. Two vols. Illustrated. Warne .. 12s. net
A pocket-guide to British wild flowers for the country rambler. Clear descriptions of 760 species, with coloured figures of 257 species.

The Evolution of Plants. By Dukinfield Henry Scott. 256 pages. Illustrated. Williams and Norgate .. .. 1s. net
A study of variation, as shown in both fossil and existing plants, pointing out especially the influence of insect life in producing modifications in plant forms. The evolution of the ferns, of the club-mosses, of the horse-tails, and of the sphenophylls is dealt with in the same way as the flowering plants.

Soil Fertility and Fertilisers. By J. E. Halligan. 397 pages. Illustrated. Williams and Norgate. 14s. 6d.
This treatise on fertilisers of all kinds is intended for the use of farmers, agricultural and horticultural students, manufacturers, and others. The language is as free from technical terms as it was possible to make it. Fertiliser formulas for various crops are given. A book of reference for the practical farmer and student rather than a book to read.

Studies in Seeds and Fruits. By H. B. Guppy. 528 pages. Williams and Norgate .. 15s. net
An interesting treatise on the processes of germination, the result of many years' original researches and experiments. The results of these untiring researches extend far beyond the immediate problems of plant life. They indicate a range of adaptability in the seed much greater than the range of conditions prevailing on the earth, from which discoveries the author proceeds to theories of cosmic evolution suggested by them. A book full of suggestiveness and very stimulating. The experiments have been conducted by exhaustive weighing, drying, and swelling of seeds in the rest stage.

British Ferns. By Francis George Heath. 140 pages. Illustrated. Pitman .. .. .. 2s. net
A "pocket-help for the collector," giving the distribution of all species of ferns throughout the United Kingdom, and enabling the traveller to identify the species which he discovers. There are illustrations and verbal descriptions of all varieties.

The Romance of Plant Life. By G. F. S. Elliot. 380 pages. Illustrated. Seeley .. 5s.
Deals vividly with the most interesting aspects of plant life in every part of the world. A great variety of subjects, treated with wide learning, yet so as to be readable by anyone over the age of fourteen.

Handbook of the British Flora. By George Bentham. Revised by Sir J. O. Hooker. 584 pages. Lovell Reeve .. .. 9s. net
This long-lived handbook, being a description of the flowering plants and ferns indigenous to the British Isles, is designed for the use of the beginner or amateur. It is very highly condensed, and is dry as dust, but has the advantage of being also full and trustworthy.

The Alpine Flora. By Henry Correvon and Philippe Robert. Translated and enlarged by E. W. Clayforth. 436 pages. Illustrated. Methuen. 16s. net
This book contains 180 coloured plates from water-colours of extreme beauty. A general account of Alpine plants and their characteristics is given, and the methods by which they may be acclimatised in gardens are described. The various species are characterised, with the treatment which they require in gardens. An

account is also given of the chief Alpine gardens in England and abroad. A truly delightful book.

Hutchinson's Popular Botany. By A. E. Knight and E. Step. Two vols. 588 pages. Illustrated. Hutchinson .. .. 15s. net
These handsome volumes, with coloured plates and a host of illustrations from photographs, form an admirable popular introduction to the subject. The living plant, from seed to fruit, is dealt with in a truly scientific way.

Our British Trees, and How to Know Them. By F. G. Heath. 492 pages. Illus. Hutchinson. 5s. net
An admirable pocket-manual, enabling the observer to identify all species. There are 250 excellent illustrations, chiefly from photographs.

Agricultural Geology. By J. E. Marr. 318 pages. Illustrated. Maps. Methuen .. 6s.
Prepared for students reading for examinations in agriculture; but, in spite of its scholastic tone, interesting to anyone who intelligently loves the countryside.

Bacteria, Yeasts, and Moulds in the Home. By H. W. Conn. 293 pages. Illustrated. Ginn. 4s. 6d.
An exceedingly interesting and useful little book, providing a scientific basis for home economy. It treats of moulds and the decay of fruit; of yeasts and their uses in fermentation of bread and of liquors; of bacteria and the preservation of food by various methods; of disease bacteria and safeguards against contagion; and of many important subjects of kindred interest.

Agriculture for Beginners. By C. W. Burkett, F. L. Stevens, and D. H. Hill. 267 pages. Illustrated. Ginn .. .. 3s. 6d.
The authors of this book believe in training children from an early age to love and understand the fundamental principles of farming. These principles are here presented in a simple and attractive manner, for the purpose of school-teaching of agriculture.

First Studies of Plant Life. By G. F. Atkinson and E. M. Wood. 266 pages. Illustrated. Ginn. 2s. 6d.
An excellent elementary school textbook of the first principles of plant anatomy and physiology.

A First Book of Forestry. By Filibert Roth. 291 pages. Illustrated. Ginn .. .. 3s. 6d.
An attempt is being made in America to make the principles of forestry more widely understood in schools and country homes, and this book, by the Chief of the United States Division of Forestry, is well designed for this purpose.

Principles of Botany. By J. Y. Bergen and B. M. Davis. 555 pages. Illustrated. Ginn. 6s. 6d.
A good advanced book for teachers, by two American botanists of high standing. Besides covering the science briefly, it also affords an introduction to economic aspects of plant life.

Botany of Today. By G. F. Scott Elliot. 352 pages. Illustrated. Seeley .. .. .. 5s. net
An account of recent discoveries, written in a fresh, open-air spirit. Deals with a great variety of subjects; e.g., bacteria, deserts, tropical forests.

The Natural History of Plants. By Anton Kerner. English translation by F. W. Oliver. Two vols. Illustrated. Blackie .. .. .. 30s.
This work is unique, in that, while accepted by botanists as authoritative, it at the same time makes plant life in its myriad forms a fascinating subject for the general reader. It deals with the form and life of plants. the living principle, absorption of food, formation of organic matter, metabolism, growth and construction; also with the history of plants, their propagation, and the origin, variation, and extinction of species. There are many excellent plates, some in colour.

Story of a Grain of Wheat. By W. C. Edgar. 195 pages. Illus. Hodder and Stoughton 1s. net
A popular account of the wheat-berry and wheat-growing, especially of the great Canadian wheatfields and their apparently exhaustless sources of food, including also the possibilities in Argentina, and in the United States. The wheat-berry itself is analytically described, and the various processes of milling reviewed.

Plant Life. By Grant Allen. 232 pages. Illustrated. Hodder and Stoughton .. .. 1s. net
A popular account, meant for men and women, not for children, of the activities of plant life in the light of the evolutionary theory. The titles of the chapters give a good index to the treatment adopted. How plants began to be; how plants came to differ from one another; how plants eat and drink; how plants marry; marriage customs; the wind as carrier; how flowers club together; what plants do for their young; the stem and branches; some plant biographies; the past history of plants.

Nervation of Plants. By Francis George Heath. 187 pages. Illustrated. Williams and Norgate. 3s. 6d. net
This book is a study, in popular language, of the cell-tissues of the different parts of plants. Cell contents; colouring matter; protoplasm; the conditions of vital force; assimilation; breathing; the influence of light; evolution; autumnal metamorphosis are some of the fascinating questions that are dealt with.

The Natural History of the Bible. By Canon Tristram. Illustrated. S.P.C.K. .. .. .. 5s.
A learned review of the physical geography, geology, and meteorology of Palestine, with a description of every animal and plant named in the Bible. The book includes an index of the texts of Scripture in which the animals and plants are mentioned.

The Principles of Horticulture. By Wilfred Mark Webb. 136 pages. Illustrated. Blackie. 2s. net
Intended to form an introduction to the theoretical side of horticulture, and written primarily for those engaged in its practice, and for the help of students for the Royal Horticultural Society's examination. Annotated diagrams are used to avoid long descriptions, and are admirably clear.

Plant Geography. By A. F. W. Schimper. English translation by W. Fisher. Edited by P. Groom and I. B. Balfour. 839 pages. Illustrations and maps. Clarendon Press .. .. 42s. net
This study of "plant-geography upon a physiological basis," written by a German professor, shows the relations of different kinds of plants, and their structure and habits, to the conditions of climate, altitude, and soil in various regions of the world. It is a fascinating work; and the illustrations, chiefly from photographs of tropical, desert, temperate,

Alpine, and other scenes of vegetation, are of unusual interest. The bibliography is excellent.

Plant Diseases. By Werner F. Bruck. English translation by J. R. Ainsworth-Davis. 152 pages. Illustrated. Blackie .. .. .. 2s. net

This excellent little treatise is of great practical use. It is distinguished from most other books on the same subject in that it treats chiefly of the effects upon the plant rather than of the character and life histories of pests.

Ancient Plants. By Marie C. Stopes. 198 pages. Illustrated. Blackie .. .. .. 4s. 6d. net

A simple account of the past vegetation of the earth and of the recent important discoveries made in this realm of Nature-study. Includes an examination of the minute structure of fossil plants, and of their resemblance to, and differences from, living ones; also a study of the past history of the various plant families. An attractive book for the younger student who is genuinely interested in evolution.

On Seedlings. By Lord Avebury. 288 pages. Illustrated. Kegan Paul .. .. 5s.

The book includes the parts of most general interest of a large, two-volume work entitled "A Contribution to our Knowledge of Seedlings." It is an examination of the forms of cotyledons, and the fact that they differ so much from the subsequent leaves.

Manual of British Botany. By C. C. Babington. 632 pages. Gurney and Jackson .. .. 9s.

A standard work, revised in the light of modern researches. Contains the flowering plants and ferns arranged according to the natural orders. Intended as a field-book for botanists.

New Creations in Plant Life: An Authoritative Account of the Life and Work of Luther Burbank. By W. S. Harwood. 430 pages. Illus. Macmillan. 7s. 6d.

A picturesque description of the new kinds and new varieties of fruits, flowers, plants, and vegetables created by Mr. Burbank. Explains the methods by which the results have been achieved, so that the reader may be in a position to undertake experiments.

Plant Life on Land. By F. O. Bower. 172 pages. Illustrated. Cambridge University Press 1s. net

A series of apparently disconnected essays on various phases of plant life; but really arranged to follow in a general way the evolutionary history of plants, so as to show the importance of the relation of the plant to water, and the migration of plant life from water to the land.

A Textbook of Fungi. By George Massee. 427 pages. Illustrated. Duckworth. .. 6s. net

Describes the surprising increase in recent years in our knowledge of fungi. Deals with the structure, functions, pathology, and classification of these humble growths, the fixation of nitrogen, the colours of fungi, and experiments on them with poisons, radium, and X-rays.

British Ferns and Their Varieties. By Charles T. Druery. 458 pages. Illus. Routledge. 7s. 6d. net

An admirable book at the price, with 40 coloured plates and 400 other illustrations. Gives the life history of ferns, their propagation, culture, and selection; fern foes and remedies; the finding of wild sports. The descriptions of varieties and species are arranged in alphabetical order.

Organography of Plants. By K. Goebel. Edited by I. B. Balfour. 2 vols. Clarendon Press. 31s. net

A study of the configuration of plants regarded as a part of their life phenomena. Treats of the organs and divisions of labour among the lower plants; differences in the formation of organs at different stages of development; the influence of external stimuli on the shape of plants. Too technical a work for the general reader, but a first-hand source of information of great interest.

Forestry for Woodmen. By C. O. Hanson. 222 pages. Illustrated. Clarendon Press. 5s. net

A thoroughly practical book on a much neglected subject. Mr. Hanson has a full knowledge of woodcraft. Taking Schlich's "Manual of Forestry" as his basis, he has produced a book which covers scientically the whole range of the woodman's work, in language that any intelligent person can understand.

The Origin of Plant Structures by Self-Adaptation to the Environment. By Rev. George Henslow. 256 pages. Kegan Paul .. .. .. 5s.

A companion volume to Mr. Henslow's "Origin of Floral Structures," endeavouring to show that environment does not "select" at all but induces a plant to form definite variations in Nature, and these variations are always in the direction of adaptation to the environment itself. To prove self-adaptation without the aid of natural selection is the book's main object.

British Trees, including the Finer Shrubs for Garden and Woodland. By C. A. Johns. Edited by E. T. Cook and W. Dallimore. 285 pages. Illustrated. Routledge. .. .. 7s. 6d. net

A standard work revised by modern authorities and embellished with many plates in colour. Deals with the forest trees of Britain and the exotic or hybrid trees and shrubs which have been introduced into the English garden.

An Introduction to Structural Botany. By D. H. Scott. Two vols. Part I.: Flowering Plants. 290 pages. Illustrated. 3s. 6d. Part II.: Flowerless Plants. 316 pages. Illustrated. Black. 3s. 6d.

A general introduction to botany, written with lucidity and freshness.

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British Fungi, with a Chapter on Lichens. By George Massee. 551 pages. Illus. Routledge. 7s. 6d. net

The primary object of this book is to enable the reader to determine the names of our native mushrooms and toadstools. Describes where and how to find the fungi; the difference between edible and poisonous kinds; and the diseases caused by these lowly vegetable growths. Illustrated with 40 coloured plates.

The Physiology of Plants. By W. Pfeffer. Translated and edited by A. J. Ewart. Three vols. Illustrated. Clarendon Press. .. .. £2 15s. net

A complete account of the present state of our

knowledge concerning the general processes of nutrition and growth and the sources of energy in plants. Too large and detailed a work for beginners, but a valuable storehouse of facts.

Studies in Fossil Botany. By D. H. Scott. 684 pages Illustrated. Black .. .. .. 10s. 6d. net
A companion volume to the author's "Introduction to Structural Botany." These studies are particularly concerned with the morphological and evolutionary aspects of the botany of earlier ages, and they are drafted in harmony with the newest results of scientific research.

Links with the Past in the Plant World. By A. C. Seward. 138 pages. Illustrated. Cambridge University Press .. .. 1s. net
An inquiry into the relative antiquity of existing plants, as shown by the records of the rocks. A few selected plants of pre-eminently ancient types are described—ferns, the sequoia, the auraucaria family, and the maiden-hair tree of China and Japan. The geographical and geological distribution of plants and their preservation as fossils are also discussed.

Œcology of Plants: An Introduction to the Study of Plant Communities. By Eugen Warming. Translated by P. Groom and I. B. Balfour. 433 pages. Clarendon Press .. .. .. 10s. 6d.
Shows how plants or plant communities adjust their forms and modes of behaviour to the amounts of available water, heat, light, nutriment. Deals with the communal life of organisms, partnership between plants and animals, or plants and plants, and the struggle between plant communities. Examines the plants that flourish in specific soils.

Bacteria and Their Products. By G. S. Woodhead. 459 pages. Illustrated. Scott .. 3s. 6d.
An account of the main facts in bacteriology and the life history of bacteria and closely allied organisms, with a discussion of the most important theories as to the part that they play in Nature's economy, especially in their relation to the various fermentative, putrefactive, and disease processes.

Elementary Botany, Theoretical and Practical. By Henry Edmonds. 274 pages. Illustrated. Longmans .. .. 2s. 6d.
A simple and elementary book for the student of botany for examination purposes. Well arranged, practical, and clearly written.

The Transition in Agriculture. By Edwin A. Pratt. 354 pages. Murray .. .. 1s.
Shows the substantial development that has taken place in subsidiary branches of rural industries following on the decline in wheat and other cereals. Encourages a spirit of confidence in the continued possibilities of the agricultural situation, and indicates what is actually being done in our country in regard to farming co-operation.

Bacteria as Friends and Foes of the Dairy Farmer. By W. Sadler. 112 pages. Illus. Methuen. 1s. 6d.
A clearly written, practical work on useful and dangerous microbes connected with the dairy industries. Discusses "starters" in cheese-making and butter-making; troubles in milk production; disease germs and milk, and the necessity for disinfecting dairies and utensils. Shows how to establish a standard quality by the scientific control of the acid germs.

Trees: A Handbook of Forest-Botany for the Woodlands and the Laboratory. By H. Marshall Ward. Five vols. Illus. Cambridge Univ. Press. 20s.
A book of great value to the forester, gardener, and general reader, as well as the student of botany and morphology. The volumes deal successively with buds and trees, leaves, flowers, and inflorescences, fruits, form and habit, each volume being complete in itself.

British Plant Galls. By E. W. Swanton. 287 pages. Illustrated. Methuen .. .. 7s. 6d. net
A volume devoted entirely to the curious excrescences on leaves, giving interesting life histories of the gall-causers—wasps, saw-flies, beetles, moths, flies, eel-worms, and fungi. Many galls are depicted in colour together with the insects that cause them. A pleasant and instructive work on an out-of-the-way yet important subject.

British Ferns, and Where Found. By E. J. Lowe. 167 pages. Illustrated. George Allen 1s.
This book, in the Young Collector series, names and describes the British ferns, and tells the districts where each is to be found. A useful compilation.

Bacteria in Relation to Country Life. By J. G. Lipman. 486 pages. Illus. Macmillan. 6s. 6d.
A discussion of the character of bacteria in rural conditions, with a view to solving many practical problems on the farm. Technical terms and expressions are omitted as far as practicable. Deals with purity of water-supply; bacteria and sewage, and soil fertility; bacteria in milk and related products.

British Plants: Their Biology and Geology. By J. F. Bevis and H. J. Jeffery. 33 pages. Illustrated. Rivers .. .. .. 4s. 6d.
A general survey of the British flora, its evolution and distribution. A useful book, not so advanced or technical as to be beyond enjoyment by the ordinary reader.

A Textbook of Agricultural Botany. By F. V. Theobald. 536 pages. Illustrated. Blackwood. 7s. 6d.
Written for students in agricultural colleges, and farmers. It considers primarily the life histories and habits of animals met with in farm and garden, particularly those which affect, for good or for evil, the stock and crops of the cultivator of the soil. A practical book.

Household Bacteriology. By E. D. and R. E. Buchanan. 536 pages. Illus. Macmillan. 10s.
Intended primarily for students in domestic science. Points out the relation between a knowledge of bacteria and the preparation and preservation of food, household sanitation, and personal hygiene. The book is really an elementary but broad survey of the science of microbe activities, with the various affairs of the household as pegs on which to hang the discussion.

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It should be remembered that in practically all cases, whether stated or not, the price of shilling and sixpenny books is *net*. "Cheap editions" indicates that several editions exist.

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A work of the widest possible range, dealing with life from protozoa to mammalia, with authority and full acquaintance with the latest scientific developments. Each branch of geology is committed to an expert, and the result is a series of scientific works, comprehensive, exact, and original. Each volume is copiously and handsomely illustrated, and separately indexed, so that it can be bought separately. Together, the ten volumes make the most complete survey of natural history.

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VOL. 7. Hemichordata, Ascidians and Amphioxus, Fishes.
VOLS. 8, 9, 10. Amphibia and Reptiles, Birds, Mammalia.

Shell Life. By Edward Step. Illustrated. Warne. 6s.
An introduction to the British mollusca, with 32 plates photographed from the actual shells, and upwards of 300 figures in the text. A useful volume for all who wish to know something of the common objects of the sea-shore. The information is arranged on a scientific basis, but it not too technical.

The World's Birds. By F. Finn. 180 pages. Illustrated. Hutchinson .. .. .. 5s. net
A practical and comprehensive classification of living birds, the description of each family being fully elaborated under the headings—diagnosis; size; form, plumage, and coloration; young; nest; eggs; incubation; food; gait; flight; note; disposition and habits; economic qualities; captivity; distribution and species.

British Serpents. By Gerald Leighton, 383 pages. Illustrated. Blackwood .. .. 5s. net
A book of great value. The only volume entirely devoted to the life history and local distribution of the native British serpent. Largely illustrated from photographs.

Origin and Metamorphoses of Insects. By Lord Avebury. 108 pages. Illustrated. Macmillan. 3s. 6d.
An introduction to the life history of insects, by the well-known naturalist, banker, and statesman, written with all the charm which he has always found in Nature-study. Many clear line-drawings illustrate the text.

Pond Life. By E. C. Ash. Illustrated. 94 pages. Jack .. .. 6d.
A guide for the young student and collector of fresh-water organisms, including full instructions for capture by drag-net and hand-net. Among the subjects discussed are microscopic wonders (e.g., diatoms, desmids, volvox, stentor, etc.); aquatic crustaceans; insects; water spiders and mites; inhabitants of the water film (the so-called pond-skaters); aquatic worms; the hydra; snails, and frogs. An excellent book for any boy with a taste for natural history.

House Flies. By C. G. Hewitt. 122 pages. Illustrated. Cambridge University Press.. 1s. net
A well written and illustrated handbook on the structure and habits of the house-fly, and especially on the part which it plays in the spreading of disease.

Zoology. By E. W. MacBride. 90 pages. Illustrated. Jack .. .. .. 6d.
A vivid sketch of the study of animal life, for the beginner. Describes the scope of zoology; its practical importance; the living substance; cells and tissues; the classification of animals; the origin of species; and the bearing of zoology on the questions of human origin and the future destiny of the race.

Embryology. By Gerald Leighton. 92 pages. Illustrated. Jack .. .. 6d.
A popular account of the problems of reproduction and the development of the embryo. The author regards some knowledge of this obscure subject as extremely valuable for those who have the responsibilities of parenthood.

British Lizards. By Gerald Leighton. 214 pages. Illustrated. Upcott Gill .. .. 5s.
The author is an eminent authority on his subject, and this book, dealing with lizards in every county, is the only volume devoted solely to the life history and local distribution of British lizards.

Industries of Animals. By Frederick Houssay. 258 pages. Illustrated. Walter Scott .. 3s. 6d
A book of fact which rivals fiction, describing the marvellous activities in humble creation, with chapters on animals that hunt, fish, and go to war; animals that provision themselves against rainy days, and build up societies; animals which make ingenious dwelling-places, and carry out defensive and sanitary work.

British Mammals. By Sir Harry Johnston. 405 pages. Illustrated. Hutchinson .. 12s. 6d. net
This handsome volume, most beautifully illustrated with coloured plates and with drawings and photographs, forms one of the series of natural history volumes of the Woburn Library, edited by the Duke of Bedford. It includes an account of the mammals of Britain from pleistocene ages to the present day.

The Infancy of Animals. By W. P. Pycraft. 272 pages. Illustrated. Hutchinson .. 6s. net
A scientific treatise, in popular language, of the appearance and habits of the young of a very large number of animals, birds, reptiles, and fishes; of great interest to the student of evolution, the observer of Nature, and for the general reader. The problems of coloration, the ways in which the young are carried, fed, and instructed, their growth and development, and many other interesting facts are treated of.

The Life of the Bee. By Maurice Maeterlinck. English translation by A. Sutro. 344 pages. George Allen .. .. 5s. net
A sympathetic and imaginative study of bee life and work, including many profound if somewhat hazy meditations on nature, instinct, destiny, etc. The book has great literary value, and some scientific interest.

Birds of the Countryside. By F. Finn. 186 pages. Illustrated. Hutchinson .. .. 5s. net
With 12 coloured plates, 118 photographs, and many outline drawings, this little pocket manual is useful to anyone who wishes to be able to identify British birds.

British Salt-Water Fishes. By F. G. Aflalo. 328 pages. Illustrated. Hutchinson .. 12s. 6d. net
Another of the handsome natural history books edited by the Duke of Bedford, and illustrated with very fine coloured plates. The author gives a scientific account of the salt-water fishes which can be described as British, summarising their habits and appearance, their distribution, and their migrations. As is here pointed out, the study of life in the seas has a practical bearing on British industrial supremacy.

British Fresh-Water Fishes. By Sir Herbert Maxwell 316 pages. Illustrated. Hutchinson. 5s. net
Another of the handsome series edited by the Duke of Bedford. The British species, which number only about fifty out of a vast variety now known to science, are described, for sake of accuracy, in scientific terminology, and afterwards with all the interesting details gathered by an expert observer. The descriptions are full of interest, and the coloured plates beautiful.

The Romance of Animal Arts and Crafts. By H. Coupin and John Lea. 356 pages. Illustrated. Seeley .. .. 5s.
In this book the activities of wild animal life are described as a fairy version of human industry—as the spinning, weaving, sewing, manufacture of paper and pottery, aeronautics, raft-building, road-making, etc., of animals, birds, and insects.

The Romance of Bird Life. By John Lea. 376 pages. Illustrated. Seeley .. .. .. 5s.
A popular study of the courtship, fighting, education, sports, toilet, migration of birds, and even their wisdom and follies.

The Romance of Insect Life. By Edmund Selous. 350 pages. Illustrated. Seeley .. 5s.
Interesting descriptions of the strange and curious in the insect world, including many kinds of ants and their remarkably ingenious customs, caterpillars, spiders, aquatic insects, scorpions, etc.

The Romance of the Animal World. By E. Selous. 330 pages. Illustrated. Seeley .. 5s.
A popular study of the ways of many animals, great and small, written in a very anthropomorphic spirit, but showing much observation and sympathy. Snails, crabs, caterpillars, ants, wasps, birds, snakes, beavers, crocodiles, whales, even the sea-serpent—all have their place.

Zoology. By A. E. Shipley and E. W. MacBride. 632 pages. Illustrated. Cambridge University Press .. .. 10s. 6d. net
This excellent textbook is designed for students who have no previous knowledge of the subject, and all technical terms are carefully explained. The authors treat animals as living creatures, and not only as dead bodies.

Agricultural Zoology. By J. Ritzema Bos. Translated by J. R. Ainsworth Davis. 312 pages. Illustrated. Methuen .. .. .. 3s. 6d.
Clear descriptions, well illustrated, of the members of the animal kingdom which are harmful or helpful to the farmer, with suggestions as to methods for getting rid of his foes. The book is intended for use in agricultural colleges, and also for the private use of the practical farmer.

The Honey Bee. By T. W. Cowan. 220 pages. Illustrated. Houlston.. .. .. 2s. 6d.
This admirable manual on the natural history, anatomy, and physiology of the bee is by the editor of the "British Bee Journal." The book is purely scientific, not a guide to bee-keeping.

Queen-Rearing in England. By F. W. L. Sladen. 56 pages. Illustrated. Houlston .. 1s.
A pamphlet dealing with bees, not princesses. It is an excellent practical manual on the breeding of good queens.

The Lore of the Honey-Bee. By Tickner Edwardes. 196 pages. Methuen .. .. .. 1s. net
An instructive and entertaining little book on the life of the bee community, with a gleaning of old beliefs and stories concerning bees, and an account of some bee-farms of to-day.

The Senses of Insects. By August Forel. English translation by M. Yearsley. 324 pages. Illustrated. Methuen .. .. .. 10s. 6d. net
A remarkable study of the senses and psychology of insects, chiefly based upon ingenious experiments designed to explore insect senses which go beyond our own. A book from which large scientific generalisations have been made.

Our Insect Friends and Foes. By F. Martin Duncan. 296 pages. Illustrated. Methuen .. 6s.
This highly interesting book not only describes numerous forms and habits of insect life, but also points out vividly their bearing upon human health and prosperity. Chapters deal with insect communities; aquatic insects; insect actors; insects in commerce; poison-fang and stiletto; insects and flowers; our beetle friends; our insect foes—ravagers of crops and transmitters of disease. The plates are very good.

Britain's Birds and Their Nests. By A. L. Thomson. 340 pages. Coloured illustrations. Chambers. 21s. net
A delightful book, dealing with all the birds of our country in their respective orders and families. The coloured drawings have been made by Mr. George Rankin from close observation of the birds and their eggs and nests.

British Birds and Their Eggs. By J. M. Boraston. 301 pages. Coloured illustrations. Chambers. 6s. net
This book, containing a new method of identification, is written for the beginner, so that he may recognise any bird from its most obvious characteristics, such as broad distinctions of colour, markings, gestures and song.

The Animal World. By F. W. Gamble. 255 pages. Williams and Norgate .. .. .. 1s. net
With an introduction by Sir Oliver Lodge. Professor Gamble, of the Birmingham University, sets forth the leading facts and principles of animal life. Among other subjects discussed are: The quest for food; the colours of animals; societies and associations; the care of the young; heredity and variation, etc.

The British Lepidoptera. By Richard South. Three vols. Illustrated. Warne .. .. 21s. net
The illustrations are the most beautiful and realistic pictures of moths that could possibly be produced. Some of them, cut out and mounted

in a glass case, are practically indistinguishable from actual specimens. Of immense value to practical entomologists. The volumes are also sold separately.

Reptiles of the World. By Raymond L. Ditmars. 391 pages. Illustrated. Pitman .. 20s. net
The photographs, by the curator of reptiles in the New York Zoological Park give this book unique value. The work is at once popular and scientific, and includes tortoises, turtles, crocodiles, lizards, and snakes, as observed in many parts of the world.

The Life and Love of the Insect. By J. H. Fabre. English translation by A. T. de Mattos. 262 pages. Black .. .. 5s.
The author of this book, who is eighty-nine years of age, has all his life been a keen and minute observer of the habits and manners of insects, and is, without doubt, the greatest entomologist of our times. This smaller work, which is a selection from his famous "Souvenirs Entomologique," is at once eminently scientific and extremely fascinating.

Butterflies and Moths of the Countryside. By F. E. Hulme. 300 pages. Illustrated. Hutchinson. 8s. 6d.
This large and handsome volume has thirty-five coloured plates by the author, showing many different species. The text describes the appearance, life-history, and localities of British moths and butterflies.

Nests and Eggs of British Birds. By F. Finn. 231 pages. Illustrated. Hutchinson .. 5s. net
An excellent and comprehensive manual of pocket size, including coloured reproductions of 154 eggs from nature, in 20 plates, reproductions of 74 eggs in half-tone, and other illustrations. Useful for the collector, and very reliable.

The Story of Animal Life. By B. Lindsay. 208 pages. Illustrated. Hodder and Stoughton. 1s. net
A readable and instructive little book, dealing especially with the advances in our knowledge of animal life due to the microscope. A classification of animals is given, and many of the minute and small forms are dealt with at some length. An interesting chapter on adaptability to circumstances and another on the methods of zoologists are added.

Reptile Life. By W. P. Pycraft. 208 pages. Illustrated. Hodder and Stoughton .. 1s. net
The author begins by distinguishing between a true reptile and such "amphibia" as frogs, toads, etc. The form and habits of some of the most interesting reptiles, such as lizards, tortoises, crocodiles, geckos, chameleons, snakes, are described in detail.

British Fisheries. By James Johnstone. 350 pages. Williams and Norgate .. .. 10s. 6d. net
A concise account of the origin and growth of British sea-fishery authorities and regulations, the methods of administration and the various problems with which our fisheries are faced, and of the best way to meet their dangers. The protection of the immature fish is regarded as the most hopeful measure.

Bird Life. By W. P. Pycraft. 244 pages. Illustrated. Hodder and Stoughton .. .. 1s. net
A most pleasantly told story of bird life—of birds as they appear, their plumage and its uses, their notes, their food, and other habits. A great deal of interesting information for the country rambler is here given in popular form. Migration, the distribution of birds in time and space, and family relationships are briefly but suggestively touched upon.

Insects. By H. Bastin. Illustrated. Jack. 7s. 6d.
A large, handsome, popular book on insects, giving in plain language the most recent knowledge with regard to their life histories and habits. The illustrations, including 40 coloured plates, are very good, and the work forms an excellent introduction to entomology.

The Vivarium. By G. C. Bateman. Illustrated. Upcott Gill .. .. 7s. 6d.
An excellent practical work on the construction, arrangement, and management of the vivarium, showing what varieties of tortoises, lizards, snakes, frogs, newts, and similar animals are suitable pets, and how to keep them in health.

Freshwater Aquaria. By G. C. Bateman. 350 pages. Illustrated. Upcott Gill .. .. 3s. 6d.
A profusely illustrated handbook, dealing with the construction, arrangement, and management of aquaria, with descriptions of suitable water-plants and live stock, and how to obtain them.

Natural History of British Fishes. By Frank Buckland. Illustrated. S.P.C.K. .. .. 3s. 6d.
A book for the general reader, giving an account of the structure and economic uses of British fishes, and their capture by net and rod, with many useful hints both to sea and fresh-water fishermen. Methods of fish-culture in ponds and hatcheries are described.

The Naturalist on the Amazons. By H. W. Bates. Cheap editions.
The author of this classical work was a friend of Charles Darwin and of A. R. Wallace, and it was with the latter that the famous expedition to the Amazons was planned and carried out. Both were keen naturalists, and Bates, who remained eleven years on the banks of the Amazons, collected in that time an enormous number of insects, some eight thousand of which were previously unknown to science.

The Naturalist in Nicaragua. By Thomas Belt. Cheap editions.
The author, one of the greatest of practical observers of last century, travelled over many parts of the world, gold-mining, and at the same time noting the wild life of the regions where he lived. In this book he gives a true and living account of the snakes and birds and strange insects of this part of Central America, where he was stationed for four years. There is no ornate language in his book, but it is vivid and full of colour.

The Geographical and Geological Distribution of Animals. By Angelo Heilprin. 435 pages. Kegan Paul .. .. 5s.
The author seeks "to give his readers such of the more significant facts connected with the past and present distribution of animals as may lead to a proper conception of the relations of existing faunas; to furnish a work of general reference, wherein the most salient features of the geography and geology of animal forms can be readily found."

Animal Life: Its Natural Conditions of Existence. By Karl Semper. 472 pages. Illustrated. Kegan Paul .. .. 5s.
The author enters upon an investigation of how variability in animal organisms is brought about by their surroundings. First he deals with inanimate surroundings—food, light, temperature, water at rest and in motion, atmosphere at rest and in motion—and then he considers living surroundings—the influence of living organisms on animal life and structure. The book formed a course of Lowell lectures.

The Dispersal of Shells. By Harry Wallis Kew. 291 pages. Illustrated. Kegan Paul .. 5s.
Dr. Alfred Russel Wallace, in a preface to this book, says that many books of far greater pretension, even though they contain descriptions of scores of new species of shells, may be of less interest than this general summary of dispersal. The writer has gathered his facts with great industry, and writes a first book with modesty.

The Senses, Instincts, and Intelligence of Animals, with Special Reference to Insects. By Lord Avebury. 292 pages. Illustrated. Kegan Paul. 5s.
In this book Lord Avebury has collected his observations and experiments with regard to the senses and intelligence of animals, particularly insects, and has prefaced his work with such information about the organs of sense generally as is needed for an understanding of the observations. The experiments are of a miscellaneous character, but of great interest. Such topics as "How do insects find their way?" are discussed.

The Mammalia in Their Relation to Primeval Times. By Oscar Schmidt. 308 pages. Illustrated. Kegan Paul .. .. 5s.
A study of the mammalia in their relation to palæontology and anthropology. After discussing the distinctive characteristics of the mammals, and their position in the animal kingdom, Professor Schmidt divides them, in a comparison of the living animals with their ancestors, into forked animals, marsupials, animals poor in teeth, hoofed animals, pair-hoofed animals, odd-hoofed animals; and then follows miscellaneous lines up to man, and the man that is to be.

Animal Parasites and Messmates. By P. J. van Beneden. 274 pages. Illustrated. Kegan Paul. 5s.
A book of the romances of the minute. The author, a professor at Louvain, who believes boldly in God-given instinct, treats animals first as messmates, then as "mutualists," and last as parasites. The parasites are either free during their own life, or while young, or when old, or they undergo metamorphoses, or they are parasites all their life long. In any case, they are interesting companions as introduced by Professor Beneden.

Spiders. By C. Warburton. 136 pages. Illustrated. Cambridge University Press 1s. net
This book is concerned with the habits and modes of life of the spiders which are most frequently met with and most easily recognised, and considerable stress is laid on the methods of research by which our modern knowledge of spiders has been obtained. The book is written with clearness and energy.

Comparative Physiology. By Louis Agassiz. English translation by Thomas Wright. 442 pages. Illustrated. Bell .. .. 5s.
An epitome of the leading principles of the science of zoology, in popular language, but treated scientifically. Though written in the middle of last century, this book still remains one of the best manuals of the subject.

Our Friend the Horse. By F. T. Barton. 276 pages. Illustrated. Dean .. .. .. 6s.
A practical guide to all breeds of horses, English and foreign ponies, asses, and mules; to the anatomy of the horse; to conformation; teeth and age; stables and stable-management; foods and feeding; horsemanship and horse-training; diseases, castration, treatment in sickness, and to the buying and selling of horses. The whole is written in a clear, brief, and systematic style, very convenient for reference.

Creatures of Other Days. By Rev. H. N. Hutchinson. 270 pages. Illustrated. Chapman and Hall. 5s. 6d.
This book, with a companion volume on "Extinct Monsters," by the same author and publishers, forms an admirable survey of the old-time creatures that have passed away from the earth. The whole of the knowledge in these volumes is practically the outcome of the research of the last two generations, and the story of these "lost creations" is in itself fascinating reading, while throwing light also on the early history of living things.

Wild Life at Home. By R. Kearton. 188 pages. Illustrated. Cassell .. .. .. 6s.
An attractive little manual by the most successful of all photographers of wild creatures, giving away the secrets which he has discovered for the benefit of all who have the perseverance to go out into the fields with a camera and profit by them. Mr. Kearton describes his own ingenious devices for stalking wild creatures with the ardour of a Nature-lover who finds this bloodless sport to excel all others. The book was written in the fields, and is illustrated with many excellent photographs of wild life.

Book of Poultry. By Lewis Wright. Revised and edited by S. H. Lewer. 627 pages. Illustrated. Cassell .. .. 21s. net.
This famous standard work has been brought up to date in accordance with the latest poultry club standards. As an authority on the various breeds of fowls, ducks, geese, swans, turkeys, and the best methods of rearing, feeding, exhibiting, and marketing, the book is unequalled.

Earthworms and Their Allies. By F. E. Beddard. 143 pages. Cambridge University Press 1s. net
Mr. Beddard introduces first the anatomical structure of the worm, describes its mode of life, discusses the relative frequency of earthworms in different regions of the world, and traces their movements and migrations. His survey includes nearly all the usually admitted genera. The literature of the subject is included under geographical divisions.

The Migration of Birds. By T. A. Coward. 130 pages. Maps. Cambridge University Press 1s. net
A fascinating subject is treated in this book in a common-sense manner by a modest author. In commenting on routes used in migration several

maps are given. Much attention is paid to the effects of wind and weather on bird flights, and Mr. Coward thinks aviators may learn much from the birds. The very good bibliography includes fifty-four volumes.

The Crayfish. By T. H. Huxley. 371 pages. Illustrated. Kegan Paul .. .. .. 5s.
In this careful study of one of the commonest and most insignificant of animals, Professor Huxley takes the reader from matters of every-day knowledge to the widest views and most difficult problems in the study of life. It is an admirable introduction to zoology.

Life in the Sea. By J. Johnstone. 150 pages. Illustrated. Cambridge University Press 1s. net
The investigation of the microscopic life of the sea has reached a point where it is worth while to make broad surveys of the life of the ocean, to consider how the different kinds of organisms affect each other, and how they are influenced by the great seasonal changes that sweep across the sea. Such a discussion of the general economy of the sea is attempted in this book.

Plant-Animals. By F. Keeble. 163 pages. Illustrated. Cambridge University Press. 1s. net
The plant-animals here discussed are two marine worms. Their nature and behaviour, as observed on the coast of Brittany, are discussed with minuteness after exhaustive observation.

Harmsworth Natural History. Three volumes. Illustrated. Educational Book Co., Ltd... 33s.
A popular survey of all living creation as it exists today, avoiding technicalities and giving the pageant of animal life picturesqueness by pen and brush. The aim has been to combine scientific authority with the interest of the story-book. Among the editors and contributors are Mr. Richard Lydekker, Sir Harry Johnston, Professor J. R. Ainsworth Davis, Dr. Alfred Russel Wallace, Professor J. A. Thomson, Professor C. Lloyd Morgan, Mr. W. H. Hudson, and many other writers.

A Book of Whales. By F. E. Beddard. 320 pages. Illustrated. Murray .. .. .. 6s. net
A comprehensive account of the cetacea, giving the main facts of their structure and mode of life, and especially dwelling on the intimate relation between structure and environment—a biological generalisation that is shown in the whales in a striking degree. The book covers ground seldom so exclusively occupied.

Extinct Animals. By E. Ray Lankester. 354 pages. Illustrated. Constable .. 3s. 6d.
A vivid and brilliant attempt to describe the vanished monsters and strange creatures that once inhabited our earth. Written by a leading man of science of the day, who combines a talent for literature with a remarkable range of knowledge, this is one of the best popular books on the subject.

Animal Locomotion; or, Walking, Swimming, and Flying, with a Dissertation on Aeronautics. By J. Bell Pettigrew. 264 pages. Illustrated. Kegan Paul .. .. 5s.
Explains in simple language some of the difficult problems in animal mechanics—how legs move by the force of gravity; the locomotion of horse, ostrich, and man; the swimming of animals and fishes, and the action of the wings of birds and bats. Has a chapter on the balloon, on artificial wings, and the nature of the forces required to propel them.

Jelly-Fish, Starfish, and Sea-Urchins: Being a Research on Primitive Nervous Systems. By G. J. Romanes. 323 pages. Kegan Paul.. 5s.
A book that made the author famous. He shows that the nervous tissue first appears on the scene of life with the qualities it displays in the higher animals. Proves the sense of smell in starfish, by keeping some of these animals without food and then putting small pieces of food near them.

Animal Mechanism. By E. J. Marey. 283 pages. Illustrated. Kegan Paul .. .. 5s.
A pioneer work by a master-hand, who designed the instruments by which his discoveries were made. Marey applied the new method of instantaneous photography to the study of galloping horses and running men. He measured the wing beats of insects by the sounds they made, and examined the muscular efforts that produced the to-and-fro movements of their wings.

Animal Intelligence. By George J. Romanes. 498 pages. Kegan Paul .. .. .. 5s.
One of the classics of the Darwinian theory. Deals with the animal mind from the point of view of evolution, and in connection with the growth of the human faculties. Begins with the lowest animals, treats of insects, fishes, reptiles, birds and mammals, and the domesticated beasts. Interesting and clearly-written book.

The Colours of Animals, Their Meaning and Use. By E. B. Poulton. 360 pages. Illustrated. Kegan Paul .. .. 5s.
Treats more particularly of the colours of insects. Shows the utility of colour and marking in animals, and gives reasons for supposing that the results have mainly been achieved by natural selection in the struggle for life. Protective resemblances, aggressive resemblances, warning colours and protective mimicry, and courtship colours are discussed.

Curiosities of Natural History. By Frank Buckland. Four vols. Macmillan .. .. 2s. 6d. each
Four delightful volumes, the outcome of many years of intimate observation.

The Protozoa. By Gary N. Calkins. 363 pages. Illustrated. Macmillan .. .. 12s. 6d. net
A summary of the most recent discoveries concerning the minute lower animals. Has an historical sketch of this branch of microscopic science; deals with the organs and functions and structure of the minute animals found in the dust of the air, in the sea, in ditches, in fresh waters and drinking waters, and in the bodies of the higher plants and animals.

The Variation of Animals and Plants under Domestication. By Charles Darwin. 2 vols. Murray. 5s. net
A collection of facts showing the amount and nature of the changes that plants and animals have undergone under man's dominion.

British Birds. By F. B. Kirkman. 96 pages. Illustrated. Jack .. .. 6d.
Contains descriptions of all the commoner species of British birds, their nests and their eggs, the object being to enable the reader to recognise the birds with ease, etc.

The Life of Crustacea. By W. T. Calman. 305 pages. Illustrated. Methuen. .. .. 6s.
Gives an account of the wonderfully diversified habits and modes of life of the large division of the animal kingdom that includes lobsters. Addressed to the general reader, and written in non-technical language, but dealing with the important scientific problems.

Insects: Their Structure and Life. A Primer of Entomology. By George H. Carpenter. 404 pages. Illustrated. Dent. .. .. .. 4s. 6d. net
A small, cheap book, sketching in outline the whole subject of the study of insect life. Gives the life history of insects. Traces their relationship, the origin of wings, and metamorphosis. Well illustrated.

The Foraminifera. By Frederick Chapman. 354 pages. Illustrated. Longmans .. 9s. net
A concise account of the foraminifera, suited to the requirements of the student of natural history and palæontology, and bringing knowledge of the life history of this and other groups of protozoa and their geographical range and distribution up to date.

The Formation of Vegetable Mould through the Action of Worms, with Observations on Their Habits. By Charles Darwin. 298 pages. Illustrated. Murray. .. .. .. 2s. 6d. net
The result of Darwin's keeping pots of earth with worms in them. He wished to learn how far a worm acted consciously, and how much mental power was displayed by animals so low in the scale of life.

The Seashore. By W. S. Furneaux. 454 pages. Illustrated. Longmans .. .. 3s. 6d. net
A very useful book by a writer who is skilful in displaying knowledge in an inviting way. It gives just the kind of guidance needed for those who are starting the study of the wonders of the sea's margin. Abundantly illustrated.

An Introduction to the Study of Mammals. By W. H. Flower and R. Lydekker. 779 pp. Ill. Black. 12s. 6d.
A comprehensive book for students, covering mammals living and extinct, and entering into considerable detail in a number of selected members of the order. It contains a copious bibliography.

Evenings at the Microscope. By P. H. Gosse. Revised by J. Bell. 434 pages. Illustrated. S.P.C.K. 5s.
A well-known introductory work to the microscopic study of life, by a brilliant naturalist of the old school. Researches among the minuter organs and forms of animal life. It has been brought up to date by Professor Bell, and many new facts and illustrations have been added.

A Handbook of British Birds. By J. E. Harting. 551 pages. Illustrated. Nimmo .. .. £2 2s.
Shows the distribution of the resident and migratory species of birds in the British islands, and gives a record of the rarer visitants. Contains in a single volume, enriched with 35 coloured plates, the precise status of every British bird, and, according to the author, conveys information of a kind not to be found in any other work on British birds.

British Birds in Their Haunts. By C. A. Johns. Revised by J. A. Owen. 326 pages. Illustrated. Routledge. .. .. 7s. 6d. net
An admirable work brought up to date, and embellished with 64 coloured plates. Contains a glossary of common and provincial names and technical terms. Many delightful stories and descriptions of the daily life of birds.

An Introduction to the Study of Fishes. By A. C. L. G. Günther. 736 pages. Illustrated. Black. 12s. 6d.
Gives in a concise form an account of the principal facts relating to the structure, classification, and life history of fishes. A very useful book of general reference.

British Dragonflies. By W. J. Lucas. 350 pages. Illustrated. Upcott Gill .. .. 10s. 6d.
A beautiful book on the life history, species, and varieties of our dragonflies, with remarks on their capture and preservation. An exhaustive treatise, adorned with 27 carefully printed plates in colour, with engravings in the text.

The Horse and Its Relatives. By R. Lydekker. 286 pages. Illustrated. George Allen .. 10s. 6d. net
A popular and yet scientifically accurate account of the natural history of the more important representatives of the horse family. Deals with the wild tarpan, the extinct forerunners of the horse, the wild ass, zebra, and quagga, and the model types of horse. Written in an interesting way, and suitable for the general reader.

Natural History. By Richard Lydekker and others. 771 pages. Illustrated. Hutchinson .. .. 5s.
A wonderful book for the price, containing an almost incredible amount of information by eight or nine authors, each one of whom is a recognised authority and original investigator in the department with which he deals.

Animal Behaviour. By C. Lloyd Morgan. 344 pages. Illustrated. Arnold .. .. 7s. 6d.
The behaviour of animals implying intelligence, emotions, and unconscious instinct. Begins with the behaviour of cells, the behaviour of plants, and traces the development of consciousness in the individual intelligence and social actions.

Experiments on Animals. By Stephen Paget. 387 pages. Nisbet. .. .. .. 4s. 6d. net.
An account of experiments on animals under the conditions of the Act of Parliament of 1876, showing the knowledge and the new means of controlling and curing disease which have been won by this kind of research.

A History of Birds. By W. P. Pycraft. 458 pages. Illustrated. Methuen .. .. 10s. 6d. net
An excellent work, written from the point of view of the evolutionist, surveying the evidence bearing on the birth and growth of various types of birds, and presenting the study of a bird as one of the living organisms moulded in part by an inherent constitution, and in part by the struggle with environment.

Our Common British Fossils. By J. E. Taylor. 331 pages. Illustrated. Routledge .. 3s. 6d.
A handy book for young students, dealing only with invertebrate fossil animals—the most numerous class of all.

The Geographical Distribution of Animals. By Alfred Russel Wallace. Two vols. Illustrated. Macmillan. .. .. £2 2s.
One of the monuments of modern biology. Contains a study of the relations of living and extinct animals bearing on the question of the past changes in the surface of the earth. The work is written in lucid language.

Outlines of Zoology. By J. Arthur Thomson. 875 pages. Illustrated. H. Froude .. 12s. 6d.
A manual for students. Gives a general survey of the animal kingdom, discusses in detail the structures and functions of animals, and the forms of vanished life recorded in the rocks and sands. Deals with the doctrine of descent, and then examines each order of animal life from the minute one-cell organism to man.

Peeps into Nature's Ways. By J. J. Ward. 320 pages. Pitman .. .. 3s. 6d. net
A capital book for students of minute forms of life, including both insects and plants. The illustrations include a large number of microphotographs taken by the author, one of the chief photographic contributors to the pages of HARMSWORTH POPULAR SCIENCE.

Injurious and Useful Insects. By L. C. Miall. 256 pages. Illustrated. Bell .. .. 3s. 6d.
A book for beginners, specially for those who are, or are likely to be, specially interested in the application of entomology to agriculture, horticulture, or forestry. First the student is introduced to insect structure; then typical insects are examined as to their life history; and last comes information for reference.

The Life of Animals: the Mammals. By Ernest Ingersoll. 555 pages. Illus. Macmillan. 8s. 6d. net
Dealing with the mode of life, the history, and the relationships of the mammals. Popular in style. Primarily American.

Natural History of Aquatic Insects. By Prof. L. C. Miall. 395 pages. Illustrated. Macmillan. 3s. 6d.
Written mainly to help young naturalists. Disregards the technical lists of zoologists. Gives very vivid descriptions of the curious forms of insect life that inhabit waters, and describes their modes of locomotion, travel, respiration, attack, defence, and egg-laying.

Insect Life: Souvenirs of a Naturalist. By Dr. J. H. Fabre. 320 pages. Illus. Macmillan. 2s. 6d.
One of the classics of modern science, by a master naturalist with a fine talent for literature. Introduces the reader into the strange, weird, wonderful world of insect life, some of the secrets of which it has taken Fabre a long life of constant, intense observation to discover. Unequalled for its studies of the living insects whose instincts are best developed.

A Textbook on Entomology. By Alpheus S. Packard. 729 pages. Illustrated. Macmillan 19s. net
A comprehensive work by an American author, designed for the use both of students and teachers. "The aim has been to afford a broad foundation for more special work by anyone who may want to study some group of insects." The chapters headings are: Morphology and Physiology, Internal Anatomy, Embryology, and Metamorphosis.

British Wild Flowers in Relation to Insects. By Lord Avebury. 194 pages. Illus. Macmillan. 4s. 6d.
A helpful little book for students, based upon original observations and notes prepared for the author's children. Technical terms are avoided as far as possible.

Reptiles, Amphibia, and Fishes. By J. T. Cunningham and others. 510 pages. Illus. Methuen. 10s. 6d. net
The life story of reptiles, amphibia, fishes, and the lower chordata—"those primitive growths which lie at the foundations of the great houses of the vertebrates"—is here told by well-known specialists. Richard Lydekker writes on reptiles; Mr. Cunningham and Dr. Boulenger on amphibia; Mr. Cunningham on fishes; and Professor J. A. Thompson on the lower forms. The plates are excellent, and some are in colour.

Economic Zoology. By Herbert Osborn. 490 pages. Illustrated. Macmillan .. .. 8s. 6d. net
Not merely a textbook for the student, but a work that may be usefully consulted by all who wish to understand the general principles that govern knowledge of the animal kingdom. The author has freely consulted the publications of the official scientific bureaus of the United States, where he is a professor of entomology.

The Horse: a Study in Natural History. By W. H. Flower. 208 pages. Illus. Kegan Paul. 2s. 6d.
Discusses the place of the horse in Nature, and its ancestors and relatives. Examines the structure of the horse in its bearing upon its manner of life, its evolution, and relation to other animal forms. A good example of a work popular yet scientific.

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Gives the history of the extermination of the great wild ox of Europe and Asia. Deals with the so-called white wild cattle of British parks, and the humped cattle of Asia and Africa; but the main theme is the domesticated breeds of ancient and modern times. Sound and clear.

Primitive Animals. By Geoffrey Smith. 156 pages. Illustrated. Cambridge University Press. 1s. net
A simple account of modern views on the relationships of the chief groups of the animal kingdom, and an outline of the evidence on which the latest classification is based.

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The Popular Natural History. By Rev. J. G. Wood. 444 pages. Illustrated. Routledge. 5s.
A favourite popular work on animal life, by a writer with a lively style. The species are described in systematic order, and the arrangement of the various links in the chain of animated Nature is explained. A pleasant introductory work, and useful to the general reader for reference.

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The Principles of Psychology. By Herbert Spencer. Two vols. 1276 pages. Williams and Norgate. 36s.
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The Mind of Man: A Textbook of Psychology. By Gustav Spiller. 552 pages. George Allen. 5s. net
Especially designed for the use of students. The volume consists of three parts: Method, general analyses, and special syntheses. It is an attempt to offer a comprehensive survey of the whole field of psychology. The author claims that each portion of the work is the outcome of research; but he also reviews, with unusual fulness, the extensive literature of the subject.

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Hallucinations and Illusions. By E. Parish. 390 pages. Scott .. .. 3s. 6d.
The International Congress of Sociology, meeting at Paris in 1899, originated an international census of waking hallucinations in the sane. The author of this book was engaged on that inquiry, with the result that he collected the information which is included in this volume, as a supplement to the results of the inquiry. An abstruse subject is treated with most industrious illustration.

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The Psychology of the Emotions. By T. Ribot. 455 pages. Scott .. .. 6s.
Professor Ribot here continues the psychology studies which gained such a sensational prominence through the theories of William James and Lange. The book consists of two parts. The first studies the more general manifestations of feeling—pleasure and pain; the second deals with special emotions—fear, anger, sympathy, social and moral feeling, the æsthetic sentiment, and abnormal and morbid characters.

The New Psychology. By E. W. Scripture. 490 pages. Illustrated. Scott .. .. 6s.
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Only in recent years has the origin of the nations of Southern Europe been rescued from the idea that all white peoples are of Aryan blood. The view now is being generally accepted that the Mediterranean peoples had a separate origin, and this contention, put forward here by Signor Sergi, Professor of Anthropology in the University of Rome, has not only gained acceptance but is being attested by the excavations in Crete and elsewhere. The case for the Mediterranean stock is here presented in a convincing manner.

The Interpretation of Dreams. By Professor Freud. George Allen .. .. 15s. net
A study of the psychological technique by which dreams can be interpreted, and upon the applica- of which every dream may be introduced into an assignable place in the psychic activity of the waking state. The author endeavours to explain processes which give rise to the strangeness and obscurity of dreams, and to discover through them the nature of the psychic forces which operate to produce the dream.

Lessons in Elementary Physiology. By Thomas H. Huxley. 611 pages. Illustrated. Macmillan. 4s. 6d.
A short, clear, business-like description of the organs and build and activities of the human body. Surveys the general field of anatomical science, and deals with the main facts of the processes of life.

The Brain and its Functions. By J. Luys. 327 pages. Kegan Paul .. .. 5s.
In the first part the writer treats of the anatomy of the brain by new methods of investigations that he discovered. In the second part he deals with the general properties of the nervous elements, the evolution of memory, dreams, the genesis of personality, ideas and sense impressions. The book is thirty-two years old, but worth reading as an introduction.

The Study of Man: An Introduction to Ethnology. By Professor A. C. Haddon. 512 pages. Illustrated. Murray .. .. .. 6s. net
A book which is intended for the general reader rather than the scientific student. It is not so much a treatise on anthropology as a collection of samples of ways in which the subject may be studied. Passing from the direct study of man, the book deals popularly with the evolution of some of his handiworks, such as the cart and the Irish jaunting-car. Even more popular are a series of chapters on country games.

Colour-Blindness and Colour-Perception. By F. W. Edridge-Green. Kegan Paul .. .. 5s.
Observations based on the examination of 116 colour-blind persons and numerous recorded cases. A practical book, based on work done for the Board of Trade. Attributes colour-blindness to diminution in the visual range, and gives instances of acquired colour-blindness. About one in five persons, according to the writer, has a diminished perception of colour, men being worse than women.

Animal Magnetism. By Alfred Binet and Charles Fère. 378 pages. Kegan Paul .. 5s.
An account of special researches into hypnotism and suggestion, undertaken chiefly at the famous French institution, the Salpêtrière. Gives history of hypnotism from Mesmer, and describes ways of producing hypnosis and the symptoms of the hypnotic states. Has a chapter on hallucinations, and one on hypnotism and responsibility.

Ethnology. By A. H. Keane. 425 pages. Illustrated. Cambridge University Press.. 10s. 6d.
Deals with the fundamental problems of the division of mankind into races, and then describes the primary racial groups. Written in a clear and interesting style by one of the masters of anthropology.

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Mind and Body: The Theories of Their Relation. By Alexander Bain. 196 pages. Kegan Paul. 5s.
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Outlines of Psychology. By H. Höffding. 365 pages. Macmillan .. .. .. 6s.
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The Psychology of Insanity. By B. Hart. 176 pages. Cambridge University Press .. .. 1s. net
A work interesting not only to the medical man, but also to the general reader, inasmuch as mental aberrations are in some degree present even in the sanest. The book is much influenced by the new and revolutionary ideas of Professor Freud of Vienna, who regards insanity not principally as a disease of the brain, but rather as arising from painful and disordered ideas. Bibliography.

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A book in two parts, the first considering the faculties of the mind involved in memory, and the second discussing the improvement of memory so as to lighten labour. The author asserts that after discovering the facts which led him to write this book he could master a subject in about one-fifth of the time it previously took him.

The Brain as an Organ of Mind. By H. Charlton Bastian. 708 pages. Illustrated. Kegan Paul. 5s.
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The Senses and the Intellect. By Alexander Bain. 671 pages. Longmans.. .. .. 15s.
This book, and a companion volume of the same size, issued by the same publishers at the same price, entitled "The Emotions and the Will," complete Bain's psychology. They are, however, now regarded as in a large degree superseded by more modern works.

Body and Mind. By William McDougall. 384 pages. Methuen.. .. .. 10s. 6d. net
The author, who is Reader in Mental Philosophy in the University of Oxford, describes his book as "a history and a defence of animism." A comprehensive survey of the problem of the relations between body and mind is given under the following form—(1) a history of the development of animism from the primitive idea of the ghost-soul to the present day; (2) a critical examination of alternative theories; (3) an attempt to state animism in a form compatible with sound epistemological principles, and with the established results of modern science.

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One of the most significant books of the present age that has only just begun to reach the consciousness of thinkers and educationists in this country. Dr. Stanley Hall, who has great influence in American education, is the first writer to appreciate adequately the enormous importance of the period of adolescence, and to discuss it in all its phases, comprising its relations to physiology, anthropology, sociology, sex, crime, religion, and education.

Principles of Physiology. By J. G. McKendrick. 242 pages. Williams and Norgate .. 1s. net
This popular review of the principles of physiology, by a well-known authority who was lately professor in the Glasgow University, is designed for readers with no scientific training.

The Human Body. By Arthur Keith. 256 pages. Williams and Norgate .. .. .. 1s. net
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The Circulation of the Blood. By William Harvey. Cheap editions.
This famous work, which revolutionised medical science, was printed in 1628 in Latin; the present translation was made 220 years later by Robert Willis.

How We Think. By John Dewey. 232 pages. Harrap .. .. 3s. 6d.
An elementary and practical study of psychology, by the Professor of Philosophy in Columbia University. Has interesting side-tracks into logic, philology, and ethics.

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Outlines of Psychology. By W. Wundt. 392 pages. Williams and Norgate .. .. 8s. net
An English translation of the great standard work in psychology, written by the founder of the modern school of physiological or experimental psychology.

Story of Life's Mechanism. By H. W. Conn. 219 pages. Illustrated. Hodder and Stoughton. 1s. net
This little treatise attempts, in the light of modern biological science, to answer the questions which arise in relation to the conception of the body as a machine. To what extent are

known physical and chemical laws and forces adequate to an explanation of the various phenomena of life? Are there any known forces which can furnish a natural explanation of the origin of the living machine?

Thought and Feeling. By F. Ryland. 219 pages. Hodder and Stoughton .. .. .. 1s. net
A popular exposition of some of the problems of psychology, dealing in a concrete and simple manner with the elementary phenomena of mental life, such as mental images; perception and illusion; how we come to know the position of things; feeling; movement and will; thought and language.

The Mind. By J. M. Baldwin. 263 pages. Illustrated. Hodder and Stoughton .. 1s. net
A definitely evolutionary study of psychology, taking into account not only introspective psychology, but also the mind of the animal, and the mind of the child. Other chapters deal with the connection of body with mind; mental diseases; "how we experiment on the mind"; suggestion and hypnotism; the training of the mind; education; social psychology; and the genius and his environment.

Psychology. By Henry J. Watt. 90 pages. Jack. 6d.
The ultimate aim of psychology is to obtain certain and unanimous knowledge regarding the constitution of mind, its history, and its destiny; and the method pursued is that of elaborate introspection. This little book is a handy introduction. It includes a bibliography.

Hypnotism. By A. M. Hutchinson. 92 pages. Jack. 6d.
Hypnotism, as the science of self-education and self-healing, and of education by suggestion as applied also to children and others, is very ably treated in this little book. The medical advantages of hypnotism are ably described, and many popular illusions in its disfavour are dispelled. There is a bibliography.

Illusions: A Psychological Study. By James Sully. 390 pages. Kegan Paul .. .. 5s.
A survey of the field of error, embracing not only the illusions of sense that may be included under a study of physiological optics, but also hallucinations, dreams, illusory introspection, and the deceits of memory and belief. A useful bibliography is included as an appendix.

The Childhood of the World. By Edward Clodd. Kegan Paul .. .. 1s.
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The Descent of Man. By Charles Darwin. 693 pages. Illustrated. Murray .. .. 2s. 6d.
The classic work on the history of the human race. Gives evidence of the descent of man from some lower form; indicates the manner of his evolution, and traces his affinities among the higher apes. The formation of races attributed slightly to conditions of life or struggle of life, but mainly to sexual selection on the part of women. Traces the principle of sexual selection among animals.

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A study in the evolution of life from the psychological side. Emotion being more fundamental than intellect, Darwin endeavours to find a connection between certain exhibitions of feelings in animals and certain instinctive expressions of emotions in man.

Hypnotism and Suggestion. By Bernard Hollander. 300 pages. Pitman .. .. .. 6s. net
The result of thirty years' practical experience of hypnotism in daily life, education, and medical practice. Dr. Hollander considers two aspects of hypnotism; first, the value of the study of its psychic phenomena; and, second, its value as a therapeutic agent for the amelioration and cure of nervous and mental disorders. There are large numbers of recorded cases in recent experiments.

The Riddle of the Universe at the Close of the Nineteenth Century. By Ernst Haeckel. Translated by J. McCabe. 348 pages. Watts .. .. 9d. net
A popular restatement of Haeckel's scheme of thought, giving his views on the lines by which man evolved from protoplasm; the evolution of the world; the "mortality of the soul," and the "equivalence of spirit and matter." It ends with a piece of somewhat empty rhetoric.

The Childhood of Art; or the Ascent of Man. By H. G. Spearing. Illustrated. Routledge. 21s. net
A clear and interesting survey of human art from the paintings of the primitive cave-men to the finest works of the Greeks, all interpreted as documents revealing the varying fortunes of man in his struggle for intellectual power and moral balance. The value of the book is enhanced by nearly 500 illustrations.

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A practical and sensible little book for parents on the dangers and safeguards for young people, in which Dr. Mary Scharlieb writes of girls, and Mr. Sibly of boys. The duty of adults to both sexes in adolescence, and methods of mental and moral training, are considered.

Ancient Hunters and Their Modern Representatives. By W. J. Sollas. 416 pp. Illus. Macmillan. 12s.
The clearest, fullest, and latest work on the study of the arts and conditions of the primitive inhabitants of Europe. Combines the most recent researches of French anthropologists and German geologists with the views of British students of the problems of prehistory. Shows that probably the ancestors of Tasmanian and African Bushmen dwelt in Europe in the warm intervals between the Great Ice Ages.

Psychology: A Short Account of the Human Mind. By F. S. Granger. 235 pages. Methuen. 2s. 6d.
A successful attempt to simplify, in language and illustration, a subject that is inevitably abstruse. A useful general introduction to the study of psychology.

Woman and Womanhood: a Search for Principles. By C. W. Saleeby. 398 pages. Heinemann. 10s. net
A clear and interesting study of the position of the civilised woman. The author has set out to furnish for the individual woman, and for those in charge of girls, a guide of life based upon the facts of physiology of sex. But he takes a wide and illuminating view of the subject, from the standpoint of a Eugenist.

Anthropology. By Edward Tylor. 463 pages. Illustrated. Macmillan .. .. .. 7s. 6d.
An admirable introduction to the study of primitive and savage man. A large and varied field of facts is surveyed in a clear, orderly manner by a leading authority, and the principal ideas are presented in an easy style suitable for the general reader. A standard work.

Man and His Handiwork. By Rev. J. G. Wood. Illustrated. S.P.C.K. .. .. .. 5s.
An interesting endeavour to trace out the history of the human race from the handiwork of man throughout the ages. The meaning of the weapons and utensils discovered by geologists, and their light on the life of the men who used them. There are about 500 pictures.

Studies of Childhood. By James Sully. 535 pages. Longmans .. .. 12s. 6d. net
The author began the detailed study of the child's mind before the fashion set in in America, and his writings have done much to foster an appreciation of childish forms of intelligence. A book for parents as well as teachers.

Teachers' Handbook of Psychology. By James Sully. 625 pages. Longmans .. .. 6s. net
The writer of this book was at one time a teacher of psychology to teachers in one of the leading training colleges. Here he gives a general survey of his subject revised up to date, and he includes a full bibliography.

The History of Mankind. By Friedrich Ratzel. Translated by A. J. Butler, with an introduction by E. B. Tylor. Three vols. Illustrated. Macmillan .. .. 36s. net
A guidebook to the study of man and civilisation. To those beginning anthropological work it gives indispensable sketches of the races of mankind, especially of the barbaric peoples who display culture in its earlier stages. The illustrations number nearly twelve hundred. Popular in treatment and scientific in spirit.

The Principles of Psychology. By William James. Two vols. Macmillan .. .. 25s. net
One of the great modern books that has profoundly influenced thinkers. The book contends that when psychology has ascertained the empirical correlation of the various sorts of thought or feeling with definite conditions of the brain it can go no further. If it goes further it becomes metaphysics. The author regards the laws of the co-existence of passing thoughts with brain-states as the ultimate laws of psychology. The book is "a mass of descriptive details running out into queries which only metaphysics can deal with."

Ambidexterity. By John Jackson. With an introduction by Major-General R. S. S. Baden Powell. 258 pages. Illustrated. Kegan Paul 6s. net
An argument for the natural development and rational training of both hands, and its effect upon the development of both parts of the brain. Deals both with the scientific and practical views of the matter, and gives a list of trades and sports in which ambidexterity is a gain.

Physiological Psychology. By William McDougall. 172 pages. Dent .. .. .. 1s. net
A book of remarkable originality and insight, showing the interaction of physiology and psychology and the value of studying them in conjunction. The author is taking a foremost place as an authority in the region of science covered broadly by this book.

Unsoundness of Mind. By Sir Thomas S. Clouston. 360 pages. Methuen .. .. .. 7s. 6d.
Written rather for the general public than for experts. The book traces the mental history of a large number of families in the Orkneys, the writer contending that there should be more public knowledge of the conditions of mental aberration. An interesting and valuable work.

Text-book of Psychology. By William James. 491 pages. Macmillan .. .. 7s. net
This is a condensation of the author's monumental "Principles of Psychology," so that it may be used for teaching purposes. Controversial questions discussed in the larger book are omitted, and some chapters necessary for the work of students are added.

Alterations of Personality. By Alfred Binet. 365 pages. Chapman and Hall .. .. 6s.
Monsieur Binet brings together a storehouse of recorded facts on such fascinating themes as successive and co-existent personalities in the same life, and changes of personality by experiments in suggestion.

Deaf Mutism. By Dr. James Kerr Love. 369 pages. Illustrated. Maclehose .. .. 9s. net
An important work on deaf mutes, produced in answer to the need of a careful study of the subject from a medical point of view. Besides discussing fully the origin of the disability in speech and hearing, the work treats of the education of deaf mutes, and surveys the various systems and their results.

The Human Mind. By James Sully. Two vols. Longmans .. .. 21s.
A textbook of psychology by a well-known authority, especially intended for those who desire a fairly full presentment of the latest results of research. Deals at some length with experimental psychology, and with illustrations of the principles on which the mind works in the abnormal conditions of insanity and hypnotism. A work of an advanced kind, but written in a clear, sound style, easy to follow.

HEALTH

The Eugenics section should also be consulted under this heading

The Health of the State. By Sir George Newman. 200 pages. Headley .. .. 1s.
An account in popular language, by an official administrator, of the rise and practice of preventive medical ideas in the sphere of social reform. The author thus describes his intention in writing: "May be looked upon in some sort as a missionary handbook, sent forth as a reminder that the physical health and fitness of

the people is the primary asset of the British Empire, and the necessary basis of that social and moral reform which has for its end 'the creation of a higher type of man.'"

Our Secret Friends and Foes. By Percy Faraday Frankland. Illustrated. S.P.C.K. .. 3s.
A popular description, by the Professor of Chemistry in the University of Birmingham, of bacteria, and of recent progress in the science of bacteriology. As the title suggests, the book deals with bacteria in relation to human life.

Handbook of Practical Hygiene. By D. H. Bergey. 164 pages. Williams and Norgate .. 6s. 6d. net
A most convenient handbook for the guidance of students in the sanitary analysis of air, water, soil, and the principal food materials, and in testing the ventilation of buildings.

Sleep and Sleeplessness. By Haydn Brown. 160 pages. Hutchinson .. .. .. 2s. 6d.
Very important advice, on a little understood subject, to sufferers from insomnia. Will be extremely helpful in all such cases.

The Hygiene of Mind. By Sir T. S. Clouston. 284 pages. Illustrated. Methuen .. .. 7s. 6d. net
This book aims at giving in popular language some of the most important facts that have been ascertained with regard to the mind, and considers the conclusions from those facts in relation to mental betterment through physiological, psychological, and medical means.

The Hygiene of School Life. By R. Crowley. 393 pages. Illustrated. Methuen .. 3s. 6d. net
A medical man who has had much care of school children, and is now an officer in the medical department of the Board of Education, discusses the best means by which their physical and mental health may be promoted. The book may be commended to parents and teachers.

Manual of Bacteriology. By A. B. Griffiths. 348 pages. Illustrated. Heinemann .. 5s.
A good popular introduction to the study of bacteria, giving special attention to laboratory methods, infectious diseases, and microbes of the air, of the soil, and of the water.

Control of Body and Mind. By Frances Gulick Jewett. 269 pages. Illustrated. Ginn. 2s. 6d.
Emphasis is laid on the care and cultivation of the special senses; on the relation of health to efficiency, mental clearness, and memory; on the influence which worry, fear, anger, hope, and joy exert over circulation, respiration, and digestion; on the power which alcohol and narcotics have to damage the nervous system and to destroy character.

Air and Health. By R. C. Macfie. 340 pages. Methuen. .. .. 7s. 6d. net
An able work, dealing with the physical and chemical properties of air, particularly with reference to health and disease. The physiology of respiration is considered in its practical bearings, and chapters are devoted to the questions of climate, dust, fogs, germs, epidemics, etc. The discussion of ventilation is interesting.

The Chemistry of Life and Health. By C. W. Kimmins. 167 pages. Illustrated. Methuen .. 2s. 6d.
This book is intended to give a concise and simple account of the various scientific laws and processes necessary to the proper understanding of the subject of hygiene. In it are described the chemical processes which effect the atmosphere; the structure of the body; the composition of water and of food substances. Ventilation, prevention of infection and of disease, and the proper cooking of food, are treated on a scientific basis.

Health and Disease. By Leslie Mackenzie. 252 pages. Williams and Norgate .. 1s. net
Dr. Leslie Mackenzie, medical member of the Local Government Board for Scotland, discusses a wide range of health subjects, including death rates, infections, antitoxins, immunity, tuberculosis, plague, disease and destitution, the evolution of the health movement, etc. Able, popular, and concise.

The New Hygiene. By Elie Metchnikoff. 104 pages. Heinemann .. .. 2s. 6d.
Three lectures delivered under the auspices of the Royal Institute of Public Health, with introduction by Sir E. Ray Lankester. They deal with the prevention of infectious diseases. Extremely suggestive.

Prevention of Tuberculosis. By Arthur Newsholme. 429 pages. Illustrated. Methuen .. 10s. 6d. net
A thorough study of the whole subject, with good bibliography. Its three parts deal respectively with the causation of tuberculosis; the means by which the mortality from this disease has already been reduced; and future preventive measures for the reduction and annihilation of tuberculosis.

Drugs and the Drug Habit. By H. Sainsbury. 307 pages. Illustrated. Methuen .. 7s. 6d. net
An eminent London physician discourses of drugs in their normal or medical use, and again in their habitual abuse by victims of unhealthy habits. Interesting and readable for those whom the subject attracts, and especially valuable to medical students.

Infancy. By T. N. Kelynack. 186 pages. Culley. 1s.
A practical little handbook, by a well-known physician, giving advice to mothers and to those who are in charge of such institutions as school for mothers, crêches, milk depots, etc. A brief statement of the laws relating to infant life and of the action of municipal bodies is included. The whole is in clear and simple language. A classified bibliography is given.

Common-Sense Dietetics. By C. L. Leipoldt. Williams and Norgate .. .. 2s. 6d. net
An excellent manual on the principles of diet, which may be recommended to the gourmet, the valetudinarian, the housekeeper, and the cook.

The Dawn of the Health Age. By Benjamin Moore, M.A., D.Sc. J. and A. Churchill .. 3s. 6d. net
An admirable and convincing volume, intended to demonstrate the necessity for entirely remodelling the present system of medical service in the interests of the whole community. The author pleads eloquently for the establishment of a national medical service, which, he maintains, is the only satisfactory service for rich and poor alike, both being attacked equally by one set of disease agents.

Public Health Problems. By John F. Sykes. 370 pages. Illustrated. Scott .. .. 3s. 6d.
A comprehensive survey of the field of public health, tracing external and internal influences on health, the varieties of communicable disease,

and the defensive measures which ought to be enforced against such diseases, with an examination of the conditions of healthy dwelling-houses, in site construction and surroundings.

Yellow-Fever and Its Prevention. By Sir Rubert W. Boyce. Illustrated. John Murray.. 10s. 6d. net
This practical manual is a summary of the author's experiences and investigations on yellow fever in New Orleans, Central and South America, the West Indies, and West Africa. The subject is treated historically, geographically, and clinically. It also contains chapters on treatment, pathology, diagnosis, and epidemiology.

Mosquito or Man? By Sir Rubert W. Boyce. Illustrated. John Murray .. .. 10s. 6d. net
A wonderful record of the progress of the campaign against the parasite. A story of the conquests of the tropical world for civilisation, bringing home to the reader the scientific and economic importance of the battle between man and the mosquito. Photographs illustrate several of the insects concerned in the propagation of disease, and there are practical illustrations showing steps in the campaign which has opened up a new world to the white races.

Dietetics. By Dr. Alexander Bryce. Jack 6d.
A careful résumé of the principles underlying the question of nutrition. The author defines food and its fundamental principles in relation to body-building.

Hygiene of Nerves and Mind in Health and Disease. By August Forel. 343 pages. Murray 6s. net
As a psychologist, especially in the fields of instinct and hypnotism, Professor Forel has a world-wide reputation. His position as director of a Swiss asylum has given him abundant opportunities for the investigation of mental disease. The results are seen in this work. Dr. Forel holds that hygienic rules whose grounds are not understood may easily do harm. Here he tries to give such a conception of popular hygiene as will enable an intelligent layman, with a fair education, to govern his life so as to avoid diseases as far as possible for himself, his fellow-men, and his offspring.

Food and the Principles of Dietetics. By Robert Hutchison. 635 pages. Illustrated. Arnold. 16s.
Designed for students and doctors, but likely to be interesting to any person desiring to acquire some knowledge of foods, and the difficult problems of nutrition. Patent and proprietary foods are examined and discussed on their merits, and certain dietetic cures and systems are criticised. Written on the whole in plain, simple English; a work of authority.

A Handbook of Physiology. By W. D. Halliburton. Illustrated. John Murray. .. .. 15s. net
A student's textbook of the very highest quality, by the Professor of Physiology at King's College, London. The work has been tested by time, having run through ten editions, and its 700 illustrations, including coloured plates, give it a double value.

Alcohol and the Human Body. By Sir Victor Horsley and Mary D. Sturge. 290 pages. Illustrated. Macmillan .. .. 1s. net
A wonderful little book, constituting an armoury of unchallengeable facts as to the effects of alcohol on health. There is a chapter by Dr. Arthur Newsholme, Chief Medical Officer of the Local Government Board, dealing with the influence of alcoholic beverages on the national health. A book for all who wish to know the real truth about alcohol.

Tropical Diseases. By Sir Patrick Manson. 896 pages. Illustrated. Cassell. .. 12s. 6d.
A manual of the diseases of warm climates, by the discoverer of the fact that some of the most dreadful maladies of tropical countries are communicated by mosquitoes and other insects. Intended principally for travellers and settlers, but forms a handy survey of the whole field of tropical diseases. Shows how the white races are at last obtaining control of the tropics. A magnificent chapter in the history of civilisation.

A Manual of Pathology. By Sidney Martin. Illustrated. John Murray. .. .. 15s. net
A comprehensive survey of the science of general pathology, illustrated with micro-photographs, which has been declared "superior to any other work of the kind in the English language." Intended for students.

The Problem of Age, Growth, and Disease. By Charles Minot. 280 pages. Illustrated. Murray. 6s. net
This book is based on lectures delivered at the Lowell Institute in 1907. It traces life through all its stages, from its inception to its apparent individual disappearance. Dr. Minot belongs to the school of scientists who hold that an agnostic position is the only possible and defensible one for a man who is loyal to the spirit of research; but he does not give the grounds for taking up this position. The work is of great but controversial interest. For example, the author ventures on the most astonishing statement that "few men after twenty-five are able to learn much."

Responsibility in Mental Disease. By Henry Maudsley. 313 pages. Kegan Paul .. 5s.
Discusses how insane persons differ from sane persons; the insane temperament; kinship between madness and various diseases; the different forms of mental derangement; the law in regard to insanity and the prevention of insanity. A standard work by a high authority on the subject, who possesses a clear and telling way of writing.

Bacteriology and the Public Health. By Sir George Newman. 497 pages. Illus. Murray. 21s. net
Dr. Newman, the Chief Medical Officer of the Board of Education, here writes with the object of supplying what is necessary for the student of hygiene and the officer of health to know concerning every-day problems of sanitation and preventive medicine. A most valuable book.

The Control of a Scourge. By Charles P. Childe. 299 pages. Methuen .. .. .. 7s. 6d. net
A work on the cure of cancer. States that a revolution has been in progress during the last quarter of a century in the treatment of cancer, and that this terrible disease is now curable by surgical operation. Has chapters on the prevention of cancer, and against quack remedies.

Milk and the Public Health. By W. G. Savage. 594 pages. Illustrated. Macmillan .. 10s. net
An attempt to measure and assess the dangers of milk, and show how they can either be

removed or diminished. Deals with bacteriology of milk and human disease; the examination of milk, and public health control of the milk supply; education of the milk trade by the rejection of dirty milk; and the necessity for continual bacteriological examinations, because nothing can take their place.

The Prevention of Malaria. By Sir Ronald Ross. Illustrated. John Murray .. .. 21s. net
Major Ross and his colleagues in the medical school of tropical medicine have here given the world a book splendidly worthy of their high reputation. There are contributions by twenty notable experts in malarial fever, and the book is perhaps the most complete exposition of the subject in the English language.

School Hygiene: the Laws of Health in Relation to School Life. By Arthur Newsholme and W. C. C. Pakes. 310 pages. Illustrated. Allen. .. 3s.
Intended for teachers, school managers, and other persons interested in the health of school children. Deals with the site and surroundings, lighting and ventilating of schools, the diet, dress, physical education of scholars, and has valuable chapters for the guidance of head-teachers on communicable diseases.

The Bacteriology of Milk. By Harold Swithinbank and Sir George Newman. Illus. Murray. 25s. net
Sir George Newman is Chief Medical Officer of the Board of Education, and has special chapters on the spread of disease by milk, and the control of the milk supply. There is no better textbook for students of the science of public health, and this book should be part of the stock-in-trade of dairyman and medical officer. A work of national value.

Infection and Immunity. By George M. Sternberg. 293 pages. Murray .. .. .. 6s. net
An attempt to study the main facts with reference to infection and immunity, with the practical object of indicating the measures necessary for the prevention of infectious diseases. The work is intended for non-medical readers, and technical terms are, as far as possible, avoided. Dr. Sternberg confines himself to what he regards as well-established facts, and does not enter upon questions raised by such remedies as "antitoxins" and German chemical specifics.

Diet in Relation to Age and Activity, with Hints Cnocerning Habits Conducive to Longevity. By Sir Henry Thompson. 134 pages. Warne 2s. net
Recommendations and advice on diet and habits, by a famous physician of very large experience and extensive practice. Simplicity in diet; water as a true food; exercise; system of meals; alcoholic liquors; dispensing with hats; the air bath; the cause of chronic disease in advancing years, are all discussed.

Food and Feeding. By Sir Henry Thompson. 320 pages. Warne .. .. .. 3s. 6d. net
No popular doctor has understood more completely than Sir Henry Thompson the part played by food in producing ill-health. Indeed, he was an expert in appreciation of the ingredients of a complete yet modest dinner. Here he puts his scientific knowledge into a popular handbook.

Functional Nerve Diseases. By A. T. Schofield. 324 pages. Methuen .. .. .. 7s. 6d. net
Deals with the nervous disorders that are "sweeping over civilised society like a plague." Attributes them to the perpetual hustle and competition of modern life, and regards them as mental phenomena rather than physical. Seeing that the mind takes a large share in the causation of many of these nerve diseases, the author argues that the mind should play a considerable part in their cure.

The Care of the Body. By F. Cavanagh. 292 pages. Methuen .. .. 7s. 6d. net
A discussion of the general principles and daily practice of health. Deals with length and conditions of sleep, cold and warm baths, exercise, fatigue and massage, the clothing, skin, hair, teeth, eyesight, and habits. A clearly written book on common-sense ways of life.

For and Against Experiments on Animals. By Stephen Paget. With an Introduction by Lord Cromer. 344 pages. Illustrated. Lewis .. .. 3s. 6d. net
Gives a clear account of the chief results obtained, during the past thirty years, by the help of experiments on animals, stated, as far as possible, in the very words of the men who did the work. Considers the anti-vivisection evidence, describes the anæsthetics used on animals, and cites the report of inspectors and the report of the Royal Commission.

The Conquest of Consumption. By A. Latham and C. H. Garland. 159 pages. Fisher Unwin 1s. net.
A résumé of the knowledge we have of the cause and prevention of consumption, with a sketch of a national scheme for preventing the spread of the malady and providing anti-tuberculosis dispensaries. The only adequate remedy for consumption, in the view of the authors, is efficient sanitorium treatment.

THOUGHT

Embracing Philosophy and its History, Political Economy, Nature, Religion, Sociology, Ethics.

See also under Man for Psychology.

English Philosophy. By Thomas M. Forsyth. 231 pages. Black .. .. .. 4s. 6d.
An outline of the development of English philosophy from Bacon to the present day, illustrating how advance in method and in results have accompanied and conditioned each other. The author finds the nature of the development in a progressive employment of the traditional English method, known distinctly as the "method of experience."

The Springs of Conduct. By C. Lloyd Morgan. 317 pages. Kegan Paul .. .. .. 3s. 6d.
An essay in the evolution of ethics, by the well-known writer on animal intelligence. Extremely fresh and vigorous. All works on ethics are curiously remote from actuality, and this one is no exception to the rule; but it is far from being as bad as most.

Humanism. By F. C. S. Schiller. 414 pages. Macmillan .. .. 10s. net
A volume of philosophical essays on the very short-lived theory of "pragmatism," which owed its origin, in about equal proportions, to

Mr. Schiller and the late Professor William James. In general, the idea of pragmatism may be given in the following formula: A judgment is true in proportion as it works. In other words, the final test of truth is practice.

Personality. By A. W. Momerie. 134 pages. Blackwood .. .. 3s.
This brief essay has had more influence in the history of thought than many great volumes. It is the brilliant reassertion of free will as against the materialists and determinists.

Essays. By Montaigne. 3 vols. Dent. 1s. net per vol.
The first expression in literature of the modern spirit, these essays should be known by everyone. This is that beautiful translation by the sixteen century John Florio.

Problems of Philosophy. By Hon. Bertrand Russell. 250 pages. Williams and Norgate .. 1s. net
An able little work, dealing rather with construction than with criticism. A good introduction to the main problems of knowledge and reality, but only of academic interest.

The Science of Life. By J. Arthur Thomson. 246 pages. Blackie .. .. .. 2s. 6d.
A short historical sketch of the evolution of the science of biology, especially in Darwinian and post-Darwinian days, showing how this science has, from insignificance, attained to a position which is central among the sciences, and of very great influence even upon the art of life itself.

Introduction to Science. By J. Arthur Thomson. 251 pages. Williams and Norgate .. 1s. net
Dr. Thomson, Professor of Natural History in Aberdeen, a profound and wide thinker, here deals with the scientific mood, the aim of science, scientific method, classification of the sciences, science and philosophy, science and art, science and religion, and the utility of science. A wonderfully suggestive book.

Foundations of Science. By W. C. D. Whetham. 93 pages. Jack .. .. 6d.
A good general introduction, suitable for the adolescent mind, dealing in order with the classification of knowledge; physical science; biological science; and psychological science. The author's method is largely historical.

Theosophy. By Mrs. Besant. 94 pages. Jack. 6d.
The leader of theosophical thought at the present day here defines the ideas and aims of this teaching. She discusses theosophy as a science, as morality and art, as philosophy, as religion. She shows the manner in which theosophists would deal with social problems, and gives an account of the Theosophical Society and its aims.

The Varieties of Religious Experience. By William James. 546 pages. Longmans .. 12s. net
A republication of the Gifford Lectures for 1901-1902. The distinguished American psychologist deals scientifically and historically with the question of conversion, and shows that we must take the recorded facts into serious account in studying changes in human character and conduct.

Progress and Poverty. By Henry George. Kegan Paul .. .. 1s.
An exposition of the single-tax theory on land, for the relief of industry. The author would tax land up to its full economic value, apart from improvement. The book is not an exposition of Socialism as is generally supposed, but a proposal for a new form of taxation, consistent with individualism.

Degeneration. By Max Nordau. Heinemann. 2s. 6d.
The best known book of the modern Jeremiah, who prophesies doom for the human race, seeing in it, physically, mentally, and psychically, signs of rapid deterioration. Critics think they observe in Nordau's own writings the excitement and hysteria he so copiously laments.

The Psychology of Childhood. By Frederick Tracy. 186 pages. Harrap .. .. .. 2s. 6d.
What are the most important characteristics of the unfolding of a child's mental life? How far is it conditioned by heredity, and how far by education? What are the outstanding features of the process by which the mind comes into conscious possession of itself? These are questions answered in this book, under the headings of the senses, intellect, feelings, will, language, æsthetic, moral, and religious ideas.

The Herbartian Psychology applied to Education. By John Adams. 284 pages. Harrap .. 3s. 6d.
Essays written with a Herbartian bias, by a professive who is not a Herbartian, but who finds Herbart's system best suited to explain educational facts. The author is a confirmed humourist, and as ready to use his humour against Herbart as against any other exponent of a big-worded psychology. A suggestive talk in a rambling way, chiefly destructive, because the author is cynically tired of the philosophical haze which surrounds education.

The Educational Ideal. By J. P. Munroe. 270 pages. Heath .. .. 3s. 6d.
A historical study of the development of the educational ideal in modern times, dealing with Rabelais, Bacon, Montaigne, Locke, Rousseau, Pestalozzi, Froebel, etc. A sound book.

Habit. By Paul Radestock. English translation by F. Caspari. 128 pages. Harrap .. 2s. 6d.
The great German educationist deals here with the importance of habit in education. It is a psychological study of great learning and equal simplicity, pointing out not only the moral and intellectual advantages of habit, but also, as is rarely done, the disadvantages of extreme habituation.

Leonard and Gertrude. By Pestalozzi. Translated by Eva Channing. 181 pages. Harrap.. 3s. 6d.
An interesting condensation of Pestalozzi's unwieldy and rambling but realistic tale with an educational moral. It makes readable a book much talked of, but little read.

Conservatism. By Lord Hugh Cecil. 252 pages. Williams and Norgate .. .. .. 1s. net
Beginning with the general conservatism which is natural to the human mind, the author deals with the history of Conservatism, and in Part II. with certain special aspects of the subject, e.g., religion and politics; property and taxation; the State and the individual. An able and interesting work.

The Socialist Movement. By J. Ramsay MacDonald. 256 pages. Williams and Norgate .. 1s. net
In this book Mr. Ramsay MacDonald, the very capable leader of the Labour Party in the House of Commons, sets out to state clearly

and authoritatively what Socialism means, and what its purpose is, and to distingush it from the many irrelevant theories with which it is often credited. The book contains a valuable classified bibliography.

Liberalism. By L. T. Hobhouse. 251 pages. Williams and Norgate .. .. .. 1s. net
An able and, in the best sense of the word, philosophical study of Liberalism and the different modes which it has assumed. Professor Hobhouse regards Liberalism principally as the political theory of progress.

The School. By J. J. Findlay. 256 pages. Williams and Norgate .. .. 1s. net
The sub-title is "an introduction to the study of education." The book gives a succinct survey of the rise and development of educational institutions, and their modern organisation; the position of the teacher; the true aims of the schools, and their efforts to promote a corporate school life. Comprehensive and ably written.

The Will to Believe, and other Essays. By William James. 349 pages. Longmans .. 7s. 6d.
Popular addresses by Professor James seeking a philosophical basis for religious belief.

Descartes: The Method, Meditations, and Selections from His Principles. By Professor J. Veitch. 473 pages. Blackwood .. .. 6s. 6d.
The best introduction to the thought of Descartes. Informative, explanatory, critical.

An Examination of Sir William Hamilton's Philosophy. By John Stuart Mill. 649 pages. Longmans. 16s.
A slashing onslaught on Hamilton's Philosophy, published in 1855. Mill took up Hamilton's works to review them, but after reading them through three times determined that he must controvert them, as representing the intuition theory. A battle of the books followed; but the conflict is now over, as modern antagonists take up other grounds of attack and defence when mental mechanics are insisted on.

Berkeley. By A. C. Fraser. 242 pages. Portrait. Blackwood .. .. 1s. net
An admirable summary account, in Blackwood's Philosophical Classics, by Professor Fraser, of Berkeley, the man and his thought. The effects of the philosopher's writings are traced through later thinkers with enthusiastic appreciation.

Descartes. By J. P. Mahaffy. 217 pages. Blackwood .. .. 1s. net
An excellent general introduction to Descartes, his method, thought, and even mathematics.

Hamilton. By John Veitch. 274 pages. Blackwood .. .. 1s. net
A summary of Sir William Hamilton's Philosophy, sufficiently full for all who are not making a special study of it to understand the bearings of Mill's attack.

Selections from Berkeley, annotated. By A. C. Fraser. 384 pages. Clarendon Press 6s.
Berkeley's Philosophy is carefully discussed with copious illustrative extracts, and is used as an introduction to the philosophies of more recent times.

Science, Matter, and Immortality.. By R. C. Macfie. 300 pages. Williams and Norgate .. 5s. net
This books presents the discoveries, the mysteries, and the limitations of modern science, showing the possibilities of idealistic improvement of the race which lie in its track, but also its need of continual open-mindedness, because of its necessarily limited scope. The author, however, has a high idea of the elevating influence which the permeation of scientific ideas is likely to have on the history of man.

A Biographical History of Philosophy. By G. H. Lewes. 680 pages. Routledge .. 3s. 6d.
A popular, almost chatty, account of the most prominent philosophers and philosophies from the earliest times to Kant. The most easily read book of its kind, but badly needs revision, some revaluations, extension up to date, and, above all, an index—the absence of which is unpardonable in such a work.

The Spiritual Interpretation of Nature. By J. Y. Simpson. 389 pages. Hodder and Stoughton. 6s. net
A conscientious attempt to bring together into some kind of harmony the beliefs of the religious consciousness with the conclusions of modern science.

Man's Origin, Destiny, and Duty. By Hugh MacColl. 201 pages. Williams and Norgate .. 4s. 6d. net
An attempt to prove that the soul and the body are different entities; that the soul will survive the body by successive transformations, and will gradually develop upwards; that the psychic universe contains numberless ascending orders of intelligent beings above the human, though they are imperceptible to man's senses; and that the whole creation is maintained and directed by one infinitely powerful and intelligent being. The execution of the work is much less comprehensive than its aim.

Henri Bergson. By H. Wildon Carr. 92 pages. Jack .. .. 6d.
This introductory sketch aims only at giving a general survey of the scope and method of the great French philosopher of today. The sub-title, "The Philosophy of Change," was chosen by M. Bergson himself, who read the proofs of the book; and the philosopher's teaching is considered under the following heads: philosophy and life; intellect and matter; instinct and intelligence; intuition; freedom; mind and body; creative evolution.

Life's Basis and Life's Ideal. By Rudolf Eucken. English translation by A. G. Widgery. 399 pages. Black .. .. 7s. 6d. net
In this work Professor Eucken discusses the leading principles of his philosophy, and its application to the different spheres of life. By a careful analysis of extant conceptions of life, and by an "inner" criticism of these, the author shows their inadequacy, the necessity for a new conception, and the direction in which he would have men seek for this.

The Life of the Spirit. By R. Eucken. 340 pages. Williams and Norgate .. .. .. 4s. 6d. net
An introduction to philosophy by a German professor of that subject, whose work has aroused much attention in Britain. Broad-minded, popular, stimulating.

The Nature of Man. By E. Metchnikoff. 309 pages. Illustrated. Heinemann .. .. 6s. net
This English translation of the "studies in optimistic philosophy," by the great Parisian pathologist, is of great interest. The author describes first an extraordinary collection of

"disharmonies in the nature of man"; then deals with religious and philosophical systems designed to diminish these; and, thirdly, with triumphant science. Very able.

Psychical Research. By Sir W. F. Barrett. 246 pages. Williams and Norgate .. 1s. net

This work, by a recent Professor of Physics in the Royal College of Science for Ireland, treats of unconscious muscular action, thought-reading, thought-transference, hypnotism and suggestion, telepathy, phantasms of the living and dead, dreams and crystal-visions, spiritualism, survival after death, etc. A fascinating little book. Bibliography.

Psychology. By William McDougall. 251 pages. Williams and Norgate .. .. 1s. net

Mr. McDougall, Reader in Mental Philosophy at Oxford, has written also valuable essays on "Body and Mind," and on "Social Psychology." Regarding psychology as the "study of behaviour," he here attempts to answer the question: "What may we hope from psychology in the way of contributing to the welfare of mankind?" Suggestive and very modern.

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Philosophy of Life. By F. von Schlegel. 567 pages. Bell .. .. 3s. 6d.
A famous work in which Christian belief is vindicated in relation to the greatest human interests. There is always something majestic and monumental about Schlegel's work.

The Wealth of Nations. By Adam Smith. Cheap editions .. ..
The book on which the modern science of political economy is based, though some of Smith's views have been effectually controverted. The book overthrew entirely the mercantile system which supposed that nations could enrich themselves by shutting off foreign trade and

hoarding gold. It proved that wealth came by the interchange of the products each country could most suitably bring into the world's general market.

The Psychology of Religion. By E. D. Starbuck. 423 pages. Diagrams. Scott .. 6s.
In a preface to this book, Professor William James, the most eminent of American psychologists, describes it as bringing compromise and conciliation into the long-standing feud between science and religion, and he recommends it as affording matter for edification and improvement to Christians and scientists alike.

The Principles of Morality. By Wilhelm Wundt. 304 pages. Allen .. .. 6s.
A volume which rounds off the scheme of Professor Wundt's views on the chief topics of ethical theory. An interesting discussion of many of the chief problems of philosophy, closing with a practical application of moral theories to the organised life of the community in the internal government of States, to the association of States with each other, and to a development of a common intellectual life.

Civilisation: Its Cause and Cure, and Other Essays. By Edward Carpenter. 175 pp. George Allen. 1s. net
Seven essays written from a Socialistic point of view, and finding the cure of present-day evils in "a complex human communism." The second essay, "A Criticism of Modern Science," is a protest against the scientific tendency to explain man by mechanics.

Munera Pulveris. By John Ruskin. G. Allen. 1s. net
Six essays on elements of political economy published in "Fraser's Magazine," and, like "Unto This Last," rejected by the general reader. Ruskin declared that they contained "the first accurate analysis of political economy published in England." In this little book, perhaps more than any other, is concentrated Ruskin's economic theory.

Sesame and Lilies. By John Ruskin. George Allen .. .. 1s. net
Two lectures, the first entitled, "Of Kings' Treasuries," on books and the sacredness of thought and language; and the second, "Of Queens' Gardens," of womanhood, first as revealed in books, and then its duties, privileges, and true domain. The most widely read of all Ruskin's works, probably because of its appeal to womanly instinct.

A Joy for Ever. By John Ruskin. Geo. Allen. 1s. net
Originally published as "The Political Economy of Art," to which were added copious addenda. The substance was given in lectures at Manchester. First the question was asked, How are we to discover genius? Second—how can it be set to work? The next lecture dealt with the accumulation of works of art, and their distribution. The whole series should be read by all who wish to know what Ruskin thought.

The Works of Ralph Waldo Emerson. 634 pages. Routledge .. .. 3s. 6d.
Much the cheapest edition of Emerson, because complete, and including six or more volumes of popular editions. The contribution of Emerson to human thought is chiefly in intellectual stimulation, and an insistent assertion of the right of the individual soul to receive the full stimulus of all the thought and experience of the race and realise itself as a compendium of mankind, an inheritor of all traditions, a focus for all nobilities, a starting point for all future acquisitions—a touch with an eternal Over-soul.

The Two Paths. By John Ruskin. Geo. Allen. 1s. net
Five lectures, the subjects being "The Deteriorative Power of Conventional Art over Nations"; "The Unity of Art"; "Modern Manufacture and Design"; "The Influence of Imagination in Architecture"; "The Work of Iron." In the last lecture Ruskin breaks forth into open Socialism. The lectures are only associated with each other in spirit, not in subject. The "two paths" are those of sincerity and insincerity.

The Crown of Wild Olive. By John Ruskin. George Allen .. .. 1s. net
A reprint of lectures pointing out the weaknesses and insincerities of modern society, and developing Ruskin's peculiar tenets of Socialistic co-operation and conscience. One of the most simple and eloquent of his books, but with a remarkably ornate introduction, designed, apparently, to influence the conduct of men by sheer oratorical power.

Time and Tide. By John Ruskin. Geo Allen. 1s. net
Elaborating Ruskin's ideas of the place of labour in the world and the responsibilities of riches. Ranking in simplicity and directness of treatment with "The Crown of Wild Olive."

Unto This Last. By John Ruskin. Geo Allen. 1s. net
Four essays on political economy and social organisation contributed to the "Cornhill Magazine," but brought to an end because they were "reprobated in the most violent manner" by the readers of that publication.

Ethics of the Dust. By John Ruskin. George Allen .. .. 1s. net
Ten lectures on crystallisation given to a girls' school, and reported in dialogue form. The lectures are not intended for an introduction to mineralogy, but to awaken in the minds of young girls, ready to work earnestly, a vital interest in the subject of their study.

The Queen of the Air. By John Ruskin. George Allen .. .. 1s. net
A study of the Greek myths of cloud and storm, memorable for its association of lovely ideas with Greek legends, and its fugue-like descriptions of natural beauty, as in the wonderful period which summarises the relations between the air and the earth.

The Groundwork of Science. By St. George Mivart. 330 pages. Murray .. .. .. 6s. net
Can there be any common ground work for science? Dr. St. George Mivart holds that there is, and, after giving a complete list of the sciences in logical sequence, he leads up to the ultimate grounds of all knowledge and of all sciences whatsoever, in what he calls the science of understanding or epistemology—a kind of superstructure for psychology and philosophy.

Treatise on Natural Philosophy. By Lord Kelvin and P. G. Tait. Two vols. Cambridge University Press .. .. 9s.
An investigation of laws in the material world, with the deduction of results. Gives a complete account of the subject in language adapted to

the non-mathematical reader, and furnishes a connected outline of the intellectual processes by which the greater part of the knowledge has been extended into regions as yet unexplored by experiment.

The Problems of Philosophy. By Dr. Harold Höffding. 201 pages. Macmillan .. .. 4s. 6d. net
The problems discussed in this profoundly thoughtful book are those of Consciousness, Knowledge, Being, and Values. William James contributed a preface to it, and arranged for a translation. He describes Professor Höffding as one of the wisest as well as most learned of living philosophers.

The Origin and Development of the Moral Ideas. By Edward Westermarck. Two vols. Macmillan. 28s.
A book of fundamental importance, by the Professor of Sociology at the University of London. The author's own summary of the book is that it comprises a study of the moral concepts, with an examination of the moral emotions, their nature and origin, and the relation between these emotions and moral concepts; a discussion of the subjects of moral judgments; a classification of the phenomena concerned; and a statement and an explanation of each class. Extraordinarily comprehensive.

A Brief History of Modern Philosophy. By Dr. Harold Höffding. 324 pages. Macmillan. 6s. 6d. net
Dr. Höffding begins his review of modern philosophy with the Renaissance, and the discovery of the natural man, and he carries it forward through all the schools of thought of England, Germany, and France to William James and Eucken, showing that the history of philosophy bears a direct relation to the general history of culture and of mind. An exceedingly valuable book, unsurpassed as a condensation by an original mind.

Lamarck: His Life and Work. By A. S. Packard. 467 pages. Illustrated. Longmans 9s.
A useful and eminently judicious survey of the life and writings of the great French evolutionist, with a sufficient introduction of his opinions in his own words to give the reader a clear conception of the theories he formulated.

Development and Purpose. By Professor L. P. Hobhouse. Macmillan .. .. .. 10s. net
A memorable survey of the latest scientific researches, resulting in the conclusion that "a conditioned purpose constitutes the core of the world-process," and that there is a Mind of which the world-purpose is the object. The book builds up the scientific probability that the story of the universe is the orderly working out of a divine thought.

SOCIETY

Primitive Man. Rise of Civilisation. Organisation of Society. Education. Government. Industry. Commerce.

Man Before Metals. By N. Joly. 365 pages. Illustrated. Kegan Paul .. .. .. 5s.
This brightly written book collects the proofs of the great age of the human race, and in a second part treats of the customs, the industry, the moral and religious ideas of man as he existed before the use of metals was known.

Relics of Primæval Life. By Sir J. W. Dawson. 336 pages. Illus. Hodder and Stoughton. 6s. net
An account of the earliest fossil traces of organic life, in the oldest rocks. The book is, however, largely concerned with the discovery of Eozoon Canadense, which was soon found to be altogether a mistake, and not an organic form at all. But there is much trustworthy geological information, and the book is written in popular language, free from technicalities.

Warfare in England. By Hilaire Belloc. 254 pages. Williams and Norgate .. .. .. 1s. net
One of our most brilliant essayists deals here with the geography of England viewed from the military and strategical standpoint, including studies of the Roman Conquest, the Norman Conquest, Mediæval Warfare, the Civil Wars, and the Scotch wars. The book is very interesting, and contains good little maps.

Rural Rides. By William Cobbett. Dent. 1s. net
Mr. Chesterton's estimate of Cobbett is that he was the last representative of that real democracy which was a return to Nature, and which only poets and mobs can understand. Few have loved the English country and the poor with the real, sturdy downrightness with which Cobbett loved them, and few, if any, have described English country scenes with the vigour and freshness and the profound simplicity with which he describes them.

The Evolution of Marriage. By C. H. Letourneau. 373 pages. Walter Scott .. .. 3s. 6d.
A valuable collection of facts gleaned from the writings of ethnographers, travellers, lawyers, and historians, tracing the growth of the marriage system through savagery to civilisation.

The Jews. By Maurice Fischberg. 578 pages. Illustrated. Walter Scott .. .. 6s.
An attempt to present the results of anthropological, pathological, psychological, and demographic investigation of the Jews. Based on careful scientific research in America and Europe. The book discusses the distribution of the Jews, their physical characters, types, customs, and occupations. There is a most useful bibliography.

The Village Community. By Sir George Laurence Gomme. 299 pages. Illustrated. Scott. 3s. 6d.
One of the first and best inquiries into the place which the village community holds among British institutions. An excellent work of reference, tracing existing relations of the village community in Britain, and examining and comparing surviving types.

Life in Early Britain. By Sir B. C. A. Windle. 244 pages. Nutt .. .. 3s. 6d.
An account of the early inhabitants of this island and the memorials which they have left behind them. Deals with Palæolithic and Neolithic man; the Bronze period; the Roman occupation of Britain; the Saxon occupation; tribal and village communities, etc.

The Origins of Invention. By Otis T. Mason. 419 pages. Illustrated. Walter Scott .. 3s. 6d.
An interesting study of industry among primitive peoples in which is traced the development of tools and mechanical devices; the uses of fire; working in stone and clay; the early uses of plants; the beginnings of textile industry; the

domestication of animals; the dawn of travel, and other aspects of progress. The author holds that all industries, arts, languages, institutions, and philosophies are inventions.

Historical Sociology. By Frank Granger. 241 pages. Methuen .. .. 3s. 6d. net
This books deals with the bases of social problems; the primary relations upon which laws and politics have actually been built up; with the individual; the will of the people; genius and destiny; marriage; religion, and regeneration. It is intended as an elementary treatise, and contains a bibliography.

Across the Bridges. By A. Paterson. Arnold. 1s.
A human and interesting story of the life of the poor of South London, presenting the pleasing and happy features, as well as the distresses, miseries, and hardships. Mr. Paterson feels himself among friends in the parts of which he writes, and consequently makes his description of them living and interesting.

At the Works. By Lady Bell. Nelson.. 1s. net
This "study of a manufacturing town" is a most systematic investigation of the life of the ironworkers and their families at Middlesbrough. Lady Bell had been intimately acquainted with the workers in this town for thirty years, and was assisted in the preparation of her book by a band of social students. Over a thousand homes were visited, and the most intimate details of their life are summarised in this little work.

The State. By Woodrow Wilson. With introduction by Oscar Browning, M.A. 656 pp. Harrap. 7s. 6d.
A study of the elements of historical and practical politics, by the man who presides over the American people. The work is worthy of a great scholar and statesman, and is interesting to all nationalities.

A Practical Guide in the Preparation of Town-Planning Schemes. By E. G. Bentley and S. P. Taylor. 160 pages. With maps. Philips 5s.
This book, which is written by a lawyer and an architect, provides a most useful and comprehensive guide to the legislation on housing, and to the best methods to follow in adopting the Housing Acts.

The Theory and Practice of Trade Unionism. By J. H. Greenwood. 70 pages. Fifield.. 6d.
The author of this useful little treatise is a barrister-at-law, and author of several books on legal subjects. A brief summary of the chief facts contained in Mr. and Mrs. Webb's book on "Industrial Democracy" is here given. The functions, aims, and methods of trade unions; arbitration and the mininum wage; apprenticeship; the future and legal status of trade unions are discussed.

Industrial Democracy. By Sidney and Beatrice Webb. 929 pages. Longmans.. .. .. 12s. net
Contains a mass of facts on the labour question in all its aspects, gathered by the authors from personal investigations. The organisation and political importance of the labour movement are admirably described.

Parliament. By Sir Courtenay Ilbert. 256 pages. Williams and Norgate .. .. .. 1s. net
This excellent little book, by the present Clerk to the House of Commons, gives a complete condensed account of the history, constitution, and practice of the English Parliament, and includes a comparison with the constitution and procedure of government in other countries. Contains a classified and critical bibliography of considerable value.

The English Language. By L. Pearsall Smith. 251 pages. Williams and Norgate .. 1s. net
Mr. Pearsall Smith, a student of American birth, but now resident near Oxford, shows in this booklet amazing industry and ingenuity in tracing the meanings of words. Every English man who loves his native language will delight in the new view of it given in this book.

History of Trade Unionism. By Sidney and Beatrice Webb. 558 pages. Longmans .. 7s. 6d. net
In describing the growth and development of the trade union movement, the authors give the political history of the English working class for nearly two hundred years. The trade union organisation of today is described in detail. The last chapter contains a realistic sketch of actual trade union life, by a trade union secretary. Includes a bibliography.

Continuation Schools in England and Elsewhere. By Michael E. Sadler. 780 pages. Manchester University Press .. .. 8s. 6d.
Professor Sadler is the acknowledged authority on the subject of continuation schools, and this comprehensive survey of their workings at home and abroad is therefore of first importance. The question of compulsion is very carefully reasoned, with a final decision in its favour, but only if applied with caution and without haste.

Housing. By Percy Alden and Edward E. Hayward. 168 pages. Headley .. .. .. 1s.
This little book, by two well-known social reformers, gives a concise account of the history of housing legislation, and an excellent brief study of the chief issues of the problem. The authors warmly support the garden-city movement. The problems of London traffic are also discussed as bearing on the housing problem, and an excellent bibliography is included.

Unemployment. By W. H. Beveridge. 405 pages. Longmans .. .. 9s. net
A new edition of a most valuable book, with a chapter on the Insurance Act. Moderate in tone, and scholarly in treatment, it reviews the whole question in a clear and reasonablo manner. The author is optimistic as to the possibility of a solution, which he believes to lie in the direction of organised fluidity of labour, and a more even distribution of work.

Life in an English Village. By Maud F. Davies. 319 pages. Unwin .. .. .. 10s. 6d. net
An account of the conditions of life in a typical small parish in Wiltshire. The social, economic, and moral aspects are dealt with, and the causes of poverty examined. The book also contains a sketch of the history of the village. A most interesting work for social students.

The Housing of the Working Classes and the Poor. By Rev. M. Kaufman. Jack .. .. 1s.
The author, who is vicar of Calthorpe in Norfolk, traces the evils of bad housing chiefly to the depopulation of the villages, and strongly advocates modification of the by-laws which hinder building in rural parishes, such as those

concerning building materials, and the compulsory purchase of land. Private effort is, he believes, to be looked to, rather than legislation for remedy.

The Housing Problem in England. By Ernest R. Dewsnup. 328 pp. Manchester University Press. 5s.
A scientific and comprehensive treatise, dealing with the statistics, legislation, and general policy on the housing question in England.

The Awakening of England. By F. E. Green. 370 pages. Illustrated. Nelson .. .. 2s. net
A popular account of things and conditions noted in rambles through rural England, with some suggestions for the revival of a happy village and country life. Mr. Green is himself a successful smallholder, and has proved by experience the value of his advice. He believes that with care and good sense those who make a living from the land could be quadrupled.

Unemployment and Trade Unions. By Cyril Jackson. 92 pages. Longmans .. .. .. 1s. 6d. net
This little treatise, by an expert, was written before the Insurance Act. It reviews the various methods of dealing with the problem, such as relief works, labour exchanges, State regulation of industry, education, insurance, etc., and indicates the lines of a remedial policy by the State, and the place of trade unions within the scheme.

Fields, Factories, and Workshops. By Prince Kropotkin. 477 pages. Nelson .. 1s. net
Discusses the advantages which civilised societies could derive from a combination of industrial pursuits with intensive agriculture, and of brain work with manual work. The decentralisation of industries, together with the development of agriculture, is put forward as the most hopeful path to social progress. Perhaps an over-optimistic point of view.

Housing of the Working Classes in London. Report of the London County Council. 168 pages. Illustrated. King .. .. 1s.
A most readable account of the various actions of the Council in dealing with the housing problem, between 1855 and 1912, especially from 1889 to 1912.

The Condition of England. By C. F. G. Masterman. 225 pages. Methuen .. .. .. 1s. net
An extremely interesting study of the people of England at the present day. Gives a most convincing picture of the real inner life of the various classes: the wealthy; the middle classes; the artisans; the very poor. A book to be read by all social students. Points out the real direction in which hope lies for the future.

Town Planning in Practice. By Raymond Unwin. 416 pages. Illustrated. Unwin .. 21s.
An introduction to the art of designing cities and suburbs, by the eminent pioneer of the garden-city movement, whose work in connection with Letchworth has been even surpassed in brilliance by his skill in laying out the Hampstead Garden Suburb.

The Return to the Land. By Senator Jules Meline. 240 pages. Chapman and Hall .. 5s.
In examining the congestion in industry, resulting from the immense and rapid development of manufactures, the author compares industrial conditions in this country with those prevailing in Japan, Germany, France, Canada, Mexico, and other countries. In advocating as a remedy a return to the land and the creation of new rural communities, the importance of opportunities for amusement and for genial intercourse is emphasised.

Rural Life Problem of the United States. By Sir Horace Plunkett. 174 pages. Macmillan. 5s. net
In this book Sir Horace Plunkett, who has done so much to revive Irish agriculture, shows how this has been accomplished working against tremendous odds; so that now it can be said that Ireland is ahead, in thought upon rural economy, of any English-speaking country. A similar policy is here advocated for the renewal of American life.

Diseases of Occupation. By Sir Thomas Oliver. 427 pages. Illustrated. Methuen .. 7s. 6d. net
A valuable survey of a rarely explored field considered from the legislative, social, and medical points of view. The author discusses factors contributing to industrial diseases, diseases due to gases, vapours, high temperatures, atmospheric conditions, chemical and metallic poisons, dust fumes, and so on. A most important book, by one of the highest authorities on the subject.

Unemployment. By B. Seebohm Rowntree and Bruno Lasker. 317 pages. Macmillan 5s. net
The authors have investigated in great detail, and carefully tabulated, the conditions and causes of unemployment in the city of York. The immediate causes were found to be chiefly a bad start in life, and the prevalence of casual work. Physical and mental inefficiency do not, in the authors' mind, suggest the real remedy for employment, which consists rather in training youths, and in the regulation and organisation of labour.

Life in West London. By Arthur Sherwell. 202 pages. Methuen .. .. .. 2s. 6d.
A study of poverty in the slums of West London, where the misery is sensibly heightened by the contrast of extreme wealth in close proximity. A human and searching study of the social, industrial, and moral conditions of the people. The author has some forcible things to say of the harm done by ignorant philanthropy.

The Civilization of China. By Herbert A. Giles. 253 pages. Williams and Norgate .. 1s. net
In this work the Professor of Chinese at Cambridge, who was formally British Consul at Mingpo, gives a most interesting account of the Chinese people, their customs, beliefs, laws and family life, showing the real nature of a great people, and dissolving many false ideas still to some extent prevalent concerning them.

Evolution of Industry. By D. H. Macgregor. 252 pages. Williams and Norgate .. 1s. net
This book, by the Professor of Political Economy at Leeds, deals with the recent changes which have given us the present condition of the working classes. Among other subjects, it deals admirably with "labour unrest," and with the relation of the people to the land.

Crime and Insanity. By C. A. Mercier. 254 pages. Williams and Norgate .. 1s. net
The well-known physician in mental diseases attempts here to discover, from the biological

standpoint, what crime actually is, and to study it in relation to insanity. Dr. Mercier's view of insanity is of great interest, as he distinguishes it altogether from *mental* disorder. He regards it as disorder *of conduct.*

Science and the Criminal. By C. Ainsworth Mitchell. 250 pages. Illustrated. Pitman .. 6s. net
This description of the various methods used by experts in the detection of crime is better reading than any detective story. Among other subjects, the book deals with methods of capture, personal identification, anthropometry, handwriting, the clues which may be found in inks and papers, and gives the history of several sensational trials.

English Political Institutions. By J. A. R. Marriott. 347 pages. Clarendon Press .. .. 4s. 6d.
The author, a lecturer and tutor in modern history and political science at Worcester College, Oxford, holds that history should be taught from the present time backwards, and so has written an introduction to English institutions explaining the contemporary working of the constitutional machine; the executive, legislative, local government, judiciary, and the relations between the Mother Country and Empire. An excellent book, non-political, clear and comprehensive.

The Americans. By Hugo Münsterberg. 618 pages. Williams and Norgate .. .. 12s. 6d. net
An attempt to interpret systematically the democratic ideals of the people of the United States, politically, economically, intellectually, and socially, from a German point of view. Written for German readers by the Professor of Psychology in Harvard University, the book is translated for American readers by a professorial colleague. The aim is to study the American man and his inner tendencies—in short, to propound a philosophy of Americanism. The keynote is struck in chapters on self-direction, self-realisation or initiative, self-perfection, and self-assertion. The author remarks caustically that he might have added self-satisfaction. A shrewd and trenchant review, showing the predominance in the American character of ethical over æsthetic tendencies.

The British Race. By John Munro. 250 pages. Hodder and Stoughton.. .. .. 1s. net
The author claims that this is the first attempt to bring the results and views of modern anthropologists, with regard to the origins of the British race, before the general public in familiar language. The book is especially interesting on the intellectual and temperamental differences of different peoples.

Life and Labour of the People of London. By Charles Booth. 17 vols. Macmillan. 5s. per vol.
An important investigation of the conditions of life and labour in London, issued during the years 1892 to 1903. Mr. Booth was assisted by many devoted workers, and the whole area was examined with astonishing minuteness. In this work appeared first an economic classification of the population which has since been used by Mr. Rowntree and others—viz., class A, lowest class; B, irregular work; C, intermittent earnings; D, small regular earnings; E, standard earnings, the latter including artisans of all kinds; F, best paid artisans and foremen; G, lower middle, including small shopkeepers and clerks; and H, including those who keep servants. It was found that about 30 per cent. of the population were in poverty (classes A-D), and about 70 per cent. in comfort (classes E-H).

Education for Citizenship. By Dr. Georg Kerschensteiner. 154 pages. Harrap.. .. 2s. 6d. net
The Commercial Club of Chicago sent an expert educationist to Europe to study education, and he found this prize essay, to which the club has given a wider publicity. The club felt the need of practical vocational training as a supplement to the public school courses, and this book gives a useful description of what is being done in Munich under the man who has not only suggested but carried out a very complete scheme of education for citizenship. The author is director of the Munich public schools.

Heredity and Selection in Sociology. By G. C. Hill. 600 pages. Black .. .. .. 12s. 6d.
The author gives in the first place a concise exposition of the main facts of heredity and selection, based upon recent biological researches; and this part of the work has been revised by Professor J. A. Thomson, the eminent Scottish biologist. Mr. Hill regards the principle of selection as having the greatest importance in social life, and believes that conflict is necessary in order to secure selection.

The Montessori Method. By Maria Montessori. Translated from the Italian. Heinemann. 7s. 6d. net
An exposition of a system for teaching very young children, or children of defective intellect, through the senses, developed after long study by an Italian lady who is a doctor and psychologist. The system has proved very successful in schools for backward children, and has attracted attention throughout the whole educational world.

Myth, Ritual, and Religion. By Andrew Lang. 720 pages. Two vols. Longmans .. 7s.
A study of religion among primitive races in all parts of the world, and among the peoples of antiquity in Egypt, India, and Greece, showing the evolution of ideas of the Divine.

Sociology. By J. Q. Dealey. Harrap. 3s. 6d. net
An attempt to simplify the teachings of sociology, and to show how they may be applied to social problems, and to cultural and moral betterment, without leading up to a Socialistic conclusion, though the writer admits the stimulating effect of social utopias.

The Factory System. By R. W. Cooke-Taylor. 189 pages. Methuen .. .. .. 2s. 6d.
A handbook containing a popular statement of how the factory system came to be, and of the controversies which have been waged with regard to it, together with a summary of legislation concerning factories. Contains a list of official forms for use under the Factory and Workshop Acts.

Crime: Its Causes and Remedies. By Cesare Lombroso. 471 pages. Heinemann.. 16s. net
A translation, under an American committee, of the French version of an Italian classic. The author describes his work as "the outlines of a system of criminal therapeutics." It discusses the chief social causes of crime. The born

criminal is held to be a distinct anthropological type, and is treated as a moral imbecile. Various existing methods of the public control of criminals are reviewed. The book is based too exclusively on Italian types, but has had a great effect on penalogy.

Applied Sociology. By Lester F. Ward. 384 pages. Ginn .. .. 10s. 6d. net
The sub-title is "the conscious improvement of society by society," and the aim is to review sociological development comprehensively in order to show that legislation of the future, which is likely to be attractive rather than prohibitory, must be produced by scientific sociologists and inventors, working on the lines of exhaustive experiment.

Physical Education. By Dudley A. Sargent. 311 pages. Ginn .. .. 6s. net
A review of physical training as needed, and in part carried out, in the United States. The arguments for athleticism and against undue athleticism are balanced carefully. There is a striking admission of the unsportsman-like sharp practice, and even ferocity, sometimes engendered in America by too keen competition.

Anthropology. By R. R. Marett. 256 pages. Williams and Norgate .. .. .. 1s. net
Mr. Marett is Reader in Social Anthropology in the University of Oxford, and an acknowledged authority on the customs and beliefs of primitive races. Anthropology, he says, studies man as he occurs at all times, and in all known parts of the world. It deals with such questions as race, language, environment, social organisation, law, religion, morality, especially in so far as individual traits reveal the universal.

The Dawn of History. By J. L. Myres. 256 pages. Williams and Norgate .. .. .. 1s. net
The author of this work is Professor of Ancient History in Oxford University. He here traces in many parts of the world the story of those crises or generally abrupt changes through which nations emerge out of the unhistoric sameness of primitive life into the striving process of the "historic age," frequently through the efforts of some individual or "great man."

The Stone Ages. By the Rev. Frederick Smith. 377 pages. Illustrated. Blackie.. .. 16s.
An account of the flint implements found in North Britain and Ireland, with deductions of great interest and importance which the author has been able to draw concerning the nature of ancient man. There is considerable evidence of his having possessed heroic qualities and great ingenuity, and possibly also domestic qualities. An extremely interesting book.

A Guide to the Antiquities of Upper Egypt. By Arthur E. P. Weigall. 594 pages. With maps and plans. Methuen .. .. .. 7s. 6d. net
The author, who is Inspector General of the Department of Antiquities, Upper Egypt, here describes with full historical details the famous ruins in his charge. The book is intended for the use of those who visit the ruins themselves, but will be interesting to all archæologists.

Extinct Civilisations of the West. By R. E. Anderson. 200 pages. Illustrated. Hodder .. 1s. net
A brief account of the traces of Norse colonies in Greenland and other parts of North America centuries before Columbus; of Welsh and Irish Celts who preceded even the Norsemen; of the Aztecs, their traditions, their hieroglyphics, their human sacrifices, religious services, their remarkable scientific knowledge, etc.; and of American archæology in general.

Extinct Civilisations of the East. By R. E. Anderson. 229 pages. Illustrated. Maps. Hodder and Stoughton .. .. 1s. net
A work on the origin and races of mankind: Chaldea and Babylonia; ancient Egypt; the Hittites, Phœnicians, and Hebrews; the Arab; and Iran, or ancient Persia. Interesting historical and ethnological chapters, valuable to the general reader and to the student of Old Testament history.

Primitive Man. By E. Clodd. 206 pages. Illustrated. Hodder and Stoughton .. 1s. net
A concise popular introduction to the study of man in the Stone and Metal Ages, containing a bibliography. The primitive ideas of barbaric nations are quoted to illustrate the probable meanings of prehistoric remains, and the positions in which they are sometimes found.

Prehistoric Times. By Lord Avebury. 616 pages. Illustrated. Williams and Norgate .. 7s. 6d. net
This history of ancient man is derived from prehistoric remains found in various parts of the world, and from a study of the manners and customs of modern savages. The book is well illustrated with pictures of implements, works of art, etc. from the prehistoric ages.

The World's Peoples. By A. H. Keane. 434 pages. Illustrated. Hutchinson .. .. 6s. net
A popular account of the bodily and mental characters, beliefs, traditions, and political and social institutions of the races of the world. Well illustrated by many photographs.

Remains of the Prehistoric Age in England. By Sir B. C. A. Windle. 312 pages. Illus. Methuen. 7s. 6d.
An interesting and well illustrated book by the President of Cork University College. It deals fully with stone, metal, and bone implements, burial places, earth-works, pit-dwellings, and with the physical remains of prehistoric man.

The Childhood of Man. By Leo Frobenius. English translation by A. H. Keane. 504 pages. Illustrated. Seeley.. .. .. .. 16s. net
An admirable description of many aspects of primitive races, including personal adornment, tattooing, tests of manhood, origin of labour, dress-language, sign and gesture language, etc.

The Position of Women in Indian Life. By the Maharani of Baroda. 358 pages. Longmans. 5s.
A book designed to forward the assimilation of Western ideas and practices by the women of India, but containing also much information with regard to their actual status. There are chapters on the woman movement; professions for women; agriculture; home professions; arts and science; co-operation, and thrift.

The Commerce of Nations. By C. F. Bastable. 226 pages. Methuen .. .. .. 2s. 6d.
Men of the present generation have in many case forgotten, or never knew, the history of the freeing of trade from hampering restrictions. The writer of this book shows how modern Protectionism has grown and flourished on ideas inimical to true progress.

Origin of Civilisation. By Lord Avebury. 482 pages. Illustrated. Longmans .. 7s. 6d. net
Lord Avebury describes the social and mental conditions of savages, their art, marriage, family relations, religion, language, polity and laws. Though the savages of today do not necessarily represent very accurately the condition of primitive man, the book is of great value to the student of social evolution.

Criminals and Crime: Some Facts and Suggestions. By Sir Robert Anderson. 194 pp. Nisbet. 5s. net
The writer of this book had in his day a good deal of experience of the criminal classes. He points out that crime against property, such as burglary and long-firm swindling, is almost always the work of a distinct type of offender, and he has his own plans—here explained—for redemption and prevention.

History of Civilisation in England. By T. H. Buckle. Three vols. .. .. .. Cheap editions
A brilliant attempt to ascertain the laws and principles of human progress, and to trace their operation in English history. A stimulating work, but inaccurate in detail, and not generally accepted nowadays. The author contends that civilisation is largely affected by natural conditions.

The Status of Woman Under the English Law. By A. B. W. and M. W. Chapman. 90 pages. Routledge. .. .. 1s. net
A compendious epitome of legislative enactments and social and political events, arranged as a continuous narrative, with references to authorities and Acts of Parliament.

The Childhood of Religions. By Edward Clodd. Kegan Paul .. .. 1s.
The early growth of religion traced, from Nature worship onward, and its development into a variety of faiths of different quality. A simple introduction to the study of comparative religion. Written in a fascinating style.

The Children: Some Educational Problems. By Alexander Darroch. 140 pages. Jack 1s.
Professor Darroch sees the life of the future in the children of the present, and holds that the whole life of the State can best be shaped through the education of its future component individuals—the children of today. A thoughtful book with a broad outlook.

The Criminal and the Community. By James Devon. 348 pages. Lane .. .. 6s. net
A useful book, by a writer who has had large experience of the criminal classes while they have been under detention. Dr. Devon comes to the conclusion which is now generally directing prison efforts—that the young should be placed largely on probation, and older criminals be trained for usefulness.

The Problem of Human Life. By Rudolph Eucken. Fisher Unwin .. .. 10s. 6d. net
A general survey of philosophic thought on the problem of human life as it has presented itself to the thinkers of successive generations. A valuable book by one of the most fertile and original thinkers of our own day.

The Task of Social Hygiene. By Havelock Ellis. 419 pages. Constable .. .. 8s. 6d.
Discusses the problems of modern civilisation, the changing status of women, and the significance of the falling birth-rate. Eugenics and love, religion, and the child, the problem of giving sexual instruction to boys and girls are among the topics discussed. The concluding chapters deal with the war against war, and the problem of international language.

Co-Operation at Home and Abroad: A Description and Analysis. By C. R. Fay. Over 400 pages. King .. .. 10s. 6d. net
A comprehensive examination of the co-operative movement as it has developed in the countries of Europe that are most advanced socially. The author shows how some phases of the movement are more suitable than others to national idiosyncracies.

The Village Labourer. By J. L. and Barbara Hammond. 428 pages. Longmans .. 9s. net
A study in the government of England before the Reform Bill, describing the life of the village poor during "the last century of the old regime," by which phrase the authors mean the time when England was governed with absolute power by a class. A valuable book, with facts not brought together elsewhere.

The Student's Froebel. By W. H. Herford. Two vols. 296 pages. Pitman .. .. .. 5s. net
A general survey of Froebel's life, theory, and works, suitable for those who wish to understand, or still more those who wish to put into practice, his system of teaching the very young. The sketch of Froebel's life is based on the biography by Seidel.

Criminal Man. By Cesare Lombroso. 342 pages. Putnam .. .. 6s.
A summary of the writings of Lombroso about the criminal type. The condensation is by the author's daughter. A general survey of the works of the Italian specialist is included. No writer needs to be read with more reserve of judgment, though the influence of his theories has been beneficent.

The Subjection of Women. By John Stuart Mill. 128 pages. Longmans .. .. .. 3s. net
The first formal examination of the relations between men and women in public life, leading up to the theory that absolute equality should exist in all civic and national respects. While the abstract argument remains the same, the illustrative circumstances of disparity between the sexes—particularly in legal respects—has have been considerably varied in favour of women since the book was written.

Thé Family. By Elsie Clewes Parsons. About 500 pages. Putnam .. .. .. 12s. 6d. net
A study in the development of the family, described as "an ethnographical and historical outline of the subject."

A History of War and Peace. By G. H. Perris. Williams and Norgate.. .. .. 1s. net
A sketch of the chief stages by which mankind has from time to time "swarmed" over the earth, with war as its forceful and ready weapon, but tending, with settlement and higher civilisation, to peaceful activity—a goal of human evolution.

Eight Chapters on the History of Work and Wages. By J. E. Thorold Rogers. 206 pp. Unwin. 2s. 6d. net
A valuable condensation, in a popular form, of the late Professor Rogers's "Six Centuries

of Work and Wages," using the facts that have a bearing on present day life. The "Six Centuries" was itself an abridgement of Rogers's most enlightening and painstaking work in eight volumes entitled "A History of Agriculture and Prices in England." A mine of information for those who regard history from economic and social standpoints.

History of Civilisation. By Charles Seignobos. 3 vols. 1303 pages. Fisher Unwin 5s. net per volume
A wide survey of the history of ancient, mediæval, and contemporary civilisation—one volume devoted to each period. Popularly written, with valuable references for supplementary reading.

Facts and Comments. By Herbert Spencer. 205 pages. Williams and Norgate .. 6s.
The last fruit from an old tree. Touches on many social subjects of present interest, and gives the great thinker's last thoughts on the ultimate questions of life.

Progress of the German Working Classes. By W. J. Ashley. 164 pages. Illus. Longmans. 1s. 6d. net
A collection of evidence to show how, in the case of Germany, Protection has been by no means inconsistent with a great advance. The author does not maintain that the tariff measures of Germany are necessarily appropriate to Great Britain. He shows, indeed, the futility of the argument from comparison.

Lombard Street. By Walter Bagehot. 359 pages. Smith and Elder .. .. .. 3s. 6d.
An account of the money-market and its relations to constitutional and commercial affairs. The money-market, Bagehot affirms, is no impalpable abstraction, but a concrete reality, and must be discussed as such. Banking in commerce, and its basal position in all enterprise, distinguishes modern methods completely from all previous methods.

The English Constitution. By Walter Bagehot. 292 pages. Kegan Paul .. .. 7s. 6d.
Describes the English Constitution as it stood in the years 1865 and 1866, since which date, as the author points out, there have been many changes in spirit and in detail. This fact hardly affects the value of the book, however; it merely carries on the process beyond its limits. The author discusses the Cabinet; the Monarchy; the House of Lords; the House of Commons; changes of Ministry, and their supposed checks and balances; the pre-requisites of Cabinet government, and the peculiar form which they have assumed in England.

The Greek Commonwealth. By Alfred E. Zimmern. 452 pages. The Clarendon Press .. 8s. 6d. net
An attempt to show clearly what Athens was really like in the fifth century before Christ. With full knowledge and keen insight the author discusses the elements of citizenship as understood in Ancient Greece, the economics of town and country, and the problems introduced by extending enterprise and power. A scholarly, thoughtful, and sympathetic book.

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Attempts a threefold task: first, to make clear the immediate work of the school doctor; second, to show that hitherto the only continuous education of the race has been through work and experience; and, last, to explain what is being attempted by the school doctor to alter the conditions of child life.

The Elements of Child Protection. By Sigmund Engel. 276 pages. George Allen .. .. 15s. net
The author studies the whole system of child protection from the joint outlook of Socialism and Darwinism. He presents all the chief problems of his subject, and in each case attempts to supply a solution.

Cash and Credit. By D. A. Barker. 143 pages. Illustrated. Cambridge University Press 1s. net
The writer describes his book as an attempt to give a sketch of the theory of money in its most practical aspect, so as to provide a stepping-stone to more detailed study. He describes cash and credit from the point of view of the counter of a country bank.

The Golden Bough. By J. G. Frazer. Illustrated. Macmillan. Seven vols. .. 10s. net per vol.
The most famous of all works on comparative religion, in any language, but, in the opinion of most students, somewhat too hypothetical. The book is, however, so charming that the reader does not very much care how far it is true; and no one will ever sift truth from error in this difficult subject. Facts from all times and places, the ancient and modern world, savages and civilised peoples, are here brought together to illustrate that inscrutable mystery of religion—the sacrifice. And they are delightful facts, too: the popular festivals of peasants in spring, midsummer, and harvest; the religion of woodmen and husbandmen and their cult of trees, and especially the "golden bough," and all kinds of sad, sweet, old pagan stories. The book has now developed into seven parts, published separately. (1) "The Magic Art and Evolution of Kings." (2) "Taboo, and the Perils of the Soul." (3) "The Dying God." (4) "Adonis, Attis, Osiris." (5) "The Spirits of the Corn and of the Wild." (6) "The Scapegoat." (7) "Balder the Beautiful."

Economic Studies. By Walter Bagehot. 280 pages. Longmans .. .. 3s. 6d.
These essays were published after the author's death, and do not represent a complete treatment of the subject; but they form a lucid and thoughtful study of some important aspects of political economy.

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An account of agricultural and social researches carried out in 1901 and 1902. A most valuable document on the condition of the countryside, full of facts bearing on the chief problem of modern English life. Here is an arsenal of facts for all interested in the resurrection of the British peasantry.

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A critical summary of the results of the science now known as criminal anthropology, or the study of the criminal as he is in himself, and as he becomes in contact with society. The author has brought together a large amount of evidence which has been collected in regard to the physical and psychical characteristics of criminals. The author deals with the treatment of criminals, and shows that intellectual education is of no value; physical and moral education and such training as will enable a person to play a part in social life are needed.

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This "short history of investment and speculation," by the editor of the "Economist," gives a vivid account of banking, stock-jobbing, the London Stock Exchange, Wall Street, good securities, and the art of investment, speculative securities, and modes of speculation, and other related subjects.

Evolution of Modern Capitalism. By J. A. Hobson. 450 pages. Scott .. .. .. 6s.
In this work Mr. Hobson traces the origin of modern capitalism; the instrument by which it works machinery; the structure of industry before machinery; the development of machine industry; the structure of modern business, trades, and markets; combinations of capital; industrial depression; the demand for labour, and the quality of labour; the economy of high wages; and the effects of modern industry on workers as consumers. A clear and well-balanced statement.

Custom and Myth. By Andrew Lang. 512 pages. Illustrated. Longmans .. .. 3s. 6d.
Consists of studies, in popular language, of some of the most interesting of primitive beliefs, fables, and ritual, including the bull-roarer; various aspects of taboo; the equivalents of some Greek myths among savages; star myths; the early history of the family; the art of savages, etc. The subjects chosen have almost all a very wide appeal, and they are treated in a manner which makes pleasant reading.

Magic and Religion. By Andrew Lang. 316 pages. Longmans .. .. 10s. 6d. net
A series of essays, forming a connected study of early religion, ritual, magic, and myth. Mr. Lang's own idea was that the earliest traceable tone of religion was relatively high, and that it was inevitably lowered in tone during the process of social evolution.

The Dawn of Civilisation. By Sir G. Maspero. 800 pages. Two vols. Illustrated. English translation by M. L. McClure. S.P.C.K. .. 24s.
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Monsieur Reclus attempts to draw the ethnic individualities of a number of the more primitive races—races that are as children, with the intelligence of a child. He chooses his subjects from all climates between the extremest polar regions and the equator. The book as a record of life is interesting, and still more as giving many forms of develpoment of the mind of primitive man.

Six Centuries of Work and Wages. By J. E. Thorold Rogers. 591 pp. Fisher Unwin .. 10s. 6d.
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The English Village Community. By Frederic Seebohm. 453 pages. Illus. Longmans. 4s. 6d. net
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Totemism. By J. G. Frazer. Four vols. Macmillan .. .. 50s. net
This pioneer book on the obscure subject of totemism was prepared by Mr. Frazer for the "Encyclopædia Britannica," but only a part of it was included in that work. The materials accumulated upon the author so that he had to publish them in a separate treatise. The work deals with the religious, sexual, and social aspects of totemism.

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A well-considered and interesting informational survey of the primary and secondary school systems of England, Germany, France, and the United States, with chapters on the education of girls and of defective children. Mr. Hughes wisely shows that each system can only be understood in its own setting, as an expression of national idiosyncracies.

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Anarchism is not merely insane violence and destruction, but has conviction and goodwill behind it, even though these be utterly mistaken. The Utopian creed of the Anarchist is well set forth here. It is to replace the present system of oppressive laws by a state of common brotherly customs. The history of the movement, with life stories of individual Anarchists.

Capital. By Karl Marx. English translation by S. Moore and E. Aveling. 800 pp. Glaisher. 10s. 6d.
One of the most famous of all works on economic science, and the basis of many Socialist arguments. It consists of a comprehensive critical analysis of capitalist protection and its effects, with a dramatic picture of the irresistible march of capitalism.

The Effects of Machinery on Wages. By J. Shield Nicholson. 143 pages. George Allen 1s. net
The author wrote as Professor of Political Economy in Edinburgh University, and here discusses machinery in its various aspects in relation to labour—the substitution of machinery for labour; machinery as auxiliary to labour; its effect on the division of labour; its influence in bringing about the concentration of labour and capital, and its effect on the mobility of capital and labour. A book of arguments rather than facts.

Money and Its Relations to Prices. By L. L. Price. 200 pages. George Allen .. .. 1s. net
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A survey of the English land system, and a comparison of the system of landlord and tenant with that of occupying ownership. The effect of the influence of both systems on the welfare of the people is discussed, and land nationalisation is held to be a necessity.

The Co-Operative Movement in Great Britain. By Mrs. Sidney Webb. 260 pages. George Allen. 2s. 6d.
A book written in the days when the author was Miss Beatrice Potter, but many times reprinted. It describes the origin and growth of the British co-operative movement as an aspect of the larger movement towards industrial democracy, and introductory chapters give a general view of the condition of the working classes early in the nineteenth century.

Essays, Scientific, Political, and Speculative. By Herbert Spencer. Three vols. Williams and Norgate .. .. 30s.
The most entertaining of Spencer's works. Forms an excellent introduction to the study of his line of thought. The principle of evolution is applied to the study of the lighter side of social affairs, such as fashions and manners and music and architecture. Has many personal touches, and covers a wide field of attraction to all who are interested in life.

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The Study of Sociology. By Herbert Spencer. 423 pages. Williams and Norgate .. 10s. 6d.
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Descriptive Sociology. By Herbert Spencer, David Duncan, Richard Scheppig, and James Collier. Eight vols. .. .. £7 15s.
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Social Statics and the Man versus the State. By Herbert Spencer. 424 pages. Williams and Norgate .. .. 10s.
In this volume Spencer unites some of his earliest and latest ideas. Published first in 1850, "Social Statics" is more brilliantly written than Spencer's other sociological works, but, although it contains the germs of many of the ideas of the synthetic philosophy, it also contains much that Spencer outgrew. The later work, "Man and the State," asserts the rights of the individual against the increasing regulative powers of governments.

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The Ancient Stone Implements, Weapons, and Ornaments of Great Britain. By Sir John Evans. 747 pages. Illustrated. Longmans .. 10s. 6d. net
The standard work on the prehistoric instruments of the early inhabitants of Great Britain. A cautious and painstaking man of science, Sir John Evans has tried to reduce to order the various small objects of human manufacture found in the river gravels, caves, and haunts of the primitive Briton.

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Money and the Mechanism of Exchange. By W. Stanley Jevons. 349 pages. Kegan Paul 5s.
A descriptive essay on the ancient and modern monetary systems of the world, and the method in which the use of money is immensely economised by the cheque and clearing system now being developed and perfected. Explains the functions of money, the mechanism of exchange, promissory notes, and the means of regulating a paper currency.

The Primitive Family in Its Origin and Development. By C. N. Starcke. 315 pages. Kegan Paul 5s.
Aims at ascertaining the nature of the primitive family, and points out the ideas on which it is based and the germ of moral growth it contains. Gives the theories of McLennan and Maine, and surveys the family arrangements of savages in all parts of the world. Discusses marriage and its development, and the dissolution of the family in the clan.

The Oldest Code of Laws in the World. By C. H. W. Johns. 88 pages. T. and T. Clark 1s. 6d. net
A complete text of the legal code of Hammurabi, King of Babylon, about 2000 B.C. The discovery of this code was hailed as the greatest event in Biblical archæology for many years. Dr. Johns is one of the highest living authorities in this branch of knowledge.

Remains of the Prehistoric Age in England. By Sir Bertram C. A. Windle. 322 pages. Illustrated. Methuen .. .. 7s. 6d. net
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An Introduction to English Economic History and Theory. By W. J. Ashley. Longmans. 15s. 6d.
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Things that Matter. By L. G. C. Money, M.P. 299 pages. Methuen. .. .. .. 5s. net
A collection of essays on social and economic questions, by a writer of authority with a clear style and an original mind. The aim of the book is to direct attention to the problems and dangers which demand the grave attention of the nation. Deals with wages and industry, prices and the cost of living, education and insurance, emigration and foreign investments.

Prehistoric Peoples. By the Marquis de Nahaillac. 412 pages. Illustrated. Putnam .. 12s. 6d.
Claims to be an epitome of the manners and monuments of prehistoric peoples. Discusses the time and duration of the Stone Age; the life and habits of the people; their weapons and industries; the origin of fire, clothing, and ornaments; the beginnings of art and social organisation; the setting up of camps and fortifications; and the dawn of surgery.

Social Evolution. By Benjamin Kidd. 385 pages Macmillan .. .. 7s. 6d. net
The forces working in the evolution of society, on the whole, effecting the greatest good of the greatest number in a progressive community. But the greatest number is comprised of the members of generations yet unborn or unthought of, and to whose interests the existing individuals are usually quite indifferent. So the social forces work for future generations more than for existing members of a society.

Betting and Gambling: A National Evil. By B. S. Rowntree. 262 pages. Macmillan .. 6d.
This valuable informational book is written by a number of well-known publicists, such as Mr. J. A. Hobson, Mr. Ramsay MacDonald, and Canon Horsley, as well as by Mr. Seebohm Rowntree, the editor. It shows the extent of gambling, and exposes its moral weakness.

Philanthropy and the State. By B. Kirkman Gray. 339 pages. P. S. King .. .. 7s. 6d.
A posthumous work, edited and expanded by Miss B. L. Hutchins. The author seeks to illustrate the historical passage from philanthropy to social politics. At present, he holds, no consistent doctrine as to the relation of the State to the weaker classes of society holds the field. The thesis he maintains is that private philanthropy cannot provide a remedy for widespread want, which results from broad and general causes; and that the provision of remedies is a proper responsibilty for the State.

The Struggle of the Nations. By Sir Gaston C. C. Maspero. 806 pages. Illustrated. S.P.C.K. 25s.
Deals with the contest for leadership between ancient Egypt, Assyria, and Syria, and the conquest of the Egyptians by the mysterious shepherd kings. Describes the early Chaldæan expeditions, and Egypt's first foreign wars.

A History of Factory Legislation. By B. L. Hutchins and A. Harrison. 298 pages. P. S. King 6s.
This very useful general sketch of the story of factory legislation, from the days of the Poor Law of Elizabeth to 1910, has deserved and

achieved considerable popularity. To the latest edition Mr. Sidney Webb contributes a preface, and briefly retells the story. The coming of the factory system is a phenomenon which every thoughtful citizen should understand. This book provides the materials.

Sweating. By Edward Cadbury and George Shann. 145 pages. Headley Brothers .. .. 1s.
The writers give, in brief yet systematic form, the facts and theories of sweated industries. As they intend the book primarily for working men, they have avoided the use of technical terms. Sweating as practised in the past and as understood at present is defined. The economic cost of it is set forth, and the causes are traced. Lastly, remedies are drafted.

Model Factories and Villages. By Budgett Meakin. 480 pages. Illustrated. Unwin .. 7s. 6d.
A study of healthy conditions of labour and housing, not from a theoretic standpoint, but from "actual experience of money-making men." Discusses social valuations, buildings, workrooms, and recreations, educational question and administrative problems, and gives accounts of model villages abroad.

The Passing of the Empires. By Sir Gaston C. C. Maspero. 836 pages. Illustrated. S.P.C.K. 25s.
The third and concluding volume of the "Dawn of Civilisation." Deals with the period in which the Egyptians gave way before the prowess of Assyria, Babylonia, and Persia, while the Grecians were busy laying the foundations of modern science, thought, and art.

A Short History of Ancient Peoples. By Robinson Souttar. 728 pages. Maps. Hodder and Stoughton .. .. 12s.
Professor Sayce writes an introduction to a volume well worthy of his compliment. A picturesque and concise account of that new-old world which modern discovery and research have disclosed. The history of each people is told completely in itself—Egypt, Babylon, Assyria, the Medes and Persians, the Hebrews, Phœnicia, Carthage, Greece, and Rome.

Garden Cities of Tomorrow. By Ebenezer Howard. 167 pages. Illustrated. George Allen. 1s. net
An interesting and inspiring little book, by the founder of the garden city movement. Shows how the attraction of the town and the attractions of the country may be combined to avoid the defects of urban and rural life.

The Control of the Tropics. By Benjamin Kidd. 101 pages. Macmillan .. .. 3s.
The inheritance of the tropics is regarded as the great object of international rivalry in the future. Denies that the coloured races, left to themselves, possess the qualities necessary to the development of the rich resources of the lands they have inherited. Holds that the European races will realise that the tropics must be ruled from the temperate regions.

Land and Labour Lessons from Belgium. By B. Seebohm Rowntree. 633 pages. Macmillan. 5s. net.
The author has set himself the task of investigating the connection between social conditions and the methods of holding land in various countries, but for the present concentrates on Belgium. There he has studied the main aspects of social and economic life for four years, with the result that the land system is described in detail—industrial questions, with the wages paid, are considered; agriculture is treated at considerable length, with transport facilities, taxation and education; and further such subjects as the standard of living, housing, destitution, and unemployment are discussed. An admirable book, packed with information.

The Nemesis of Nations. By W. Romaine Paterson. 348 pages. Dent .. .. .. 10s. 6d. net
The author holds that slavery was the foundation of ancient states, and his book deals with the law of slavery as the first law of nations, namely, "that masters have the power of life and death over slaves, and whatever the slave earns he earns for his master." Later he proposes to show how slavery became serfdom, and serfdom has become poverty. Meantime, he traces the effect of slavery on the ancient world, in Hindustan, Babylon, Greece, and Rome.

Rough Stone Monuments and Their Builders. By T. Eric Peet. 172 pages. Ill. Harper. 2s. 6d. net
Written to enable those interested in Stonehenge and other great primitives monuments of Britain to learn something of similar buildings existing in different parts of the world. A summary of the latest researches on the subject, by one of the leading authorities of the younger generation.

Sweated Industry. By Clementina Black. 281 pages. Duckworth. .. .. 2s. net.
"Sweating" is applied in this book to any method of work under which the workers are extremely ill-paid or extrememly overworked. Miss Clementina Black has a remarkable knowledge of the subject, and brings together startling facts respecting "the poorest of all," workers in factories, shop-assistants, clerks, waitresses, traffic workers, and wage-earning children. She also discusses at length the question of a minimum wage.

EUGENICS

Human Welfare. Social Betterment. Future of the Race.

Heredity and Eugenics. By J. M. Coulter and others. 312 pages. Illustrated. Cambridge University Press .. .. 10s.
This book, the work of leading investigators in the new science of eugenics, is written for the general public, and presents the latest conclusions in an interesting way. Several notable pedigrees of families are given.

Love and Marriage. By Ellen Key. 399 pages. Putnam .. .. 6s. net
A famous work on the chief social problem. The matter is regarded by the writer from the point of view of motherhood, and all customs and laws regarding the relations of the sexes are studied as they affect the children.

Report of the Inter-Departmental Committee on Physical Deterioration. 177 pages. Government publication .. .. 1s. 3d.
A weighty State document which no student of national welfare can afford to ignore.

The Town Child. By Reginald A. Bray. 255 pages. Unwin .. .. 3s. 6d. net
An interesting and profound study of the influences which are at work moulding the

character and outlook of the town child; of the reciprocal action of environment on man and of man on environment; and of the social importance of the family life and other real small associations in which the child grows up.

Heredity in Relation to Eugenics. By Charles Benedict Davenport. 298 pages. Illustrated. Williams and Norgate .. .. .. 8s. 6d. net
In this important pioneer work, the Director of the Department of Experimental Evolution in the Carnegie Institution of Washington lays down a method, on Mendelian lines, for the study of heredity. He holds that for a long time investigation must be the watchword, and he seeks to show how the investigation may be most profitably carried on. A book of extreme interest and high value.

Hereditary Genius. By Sir Francis Galton. 406 pages. Macmillan. .. .. 7s. net
This work, by the "father of eugenics," is a statistical consideration of the question whether genius be hereditary or no, and incidentally of many kindred questions. Some three hundred families are dealt with, containing between them nearly a thousand eminent men, illustrating various kinds of genius.

Inquiries into Human Faculty and its Development. By Sir Francis Galton. 256 pages. Dent. 1s. net
An important work by the pioneer of eugenics, who says in his introduction that his object has been "to take note of the varied hereditary faculties of different men, and of the great differences in different families and races, to learn how far history may have shown the practicability of supplanting inefficient human stock by better strains, and to consider whether it might not be our duty to do so by such efforts as may be reasonable."

The Children of the Nation. By Sir John E. Gorst. 297 pages. Methuen .. .. .. 7s. 6d. net.
The various problems concerning the welfare of children, such as their physical fitness, education, training, are here weighed and fully discussed from the point of view of their importance to the well-being of the State. The extremely bad policy of neglecting the children in any way is pointed out under every aspect.

Education and Heredity. By J. M. Guyau. 301 pages. Scott .. .. 3s. 6d.
The main value of Monsieur Guyau's work is to be found in the point of view from which it is written. The ultimate good of society is ever present to his mind as the one standard by which to estimate all educational aims and methods. He hold that the good of the individual is only to be found in social activity, and that the education is misplaced which does not tend to the progress of the race. He therefore gives the highest value to ethical education.

The Bitter Cry of the Children. By John Spargo. 337 pages. Illustrated. Macmillan .. 6s. 6d. net
A weighty book in the campaign against the destruction of child life, based on investigations in America, but largely international. The writer deals with the school child, the working child, the provision of pure milk, classes for girls, supervision of patent foods, abolition of child labour, etc.

The Dependent, Defective, and Delinquent Classes. By C. R. Henderson. 397 pages. Harrap. 7s. 6d.
A valuable study of the social treatment of the unfit, by the Professor of Sociology in the University of Chicago. A fresh and interesting work on all forms of social endeavour.

Degeneracy. By E. S. Talbot. 366 pages. Illustrated. Scott .. .. 6s.
Only in recent years has the explanation of degeneracy been scientifically traced and its factors identified. Here Dr. Talbot brings together his notion of the causes of arrested development and various forms of abnormality. The book is for professional and popular reading.

Child Life and Labour. By Margaret Alden. 184 pages. Headley Brothers .. .. 1s.
A very useful little book, pervaded by a fine sense of humanity. It brings together much information respecting the exploitation of child-life and its necessary defence. There are summaries, excellent for reference, of societies dealing with the subject of legislation, and books.

The Methods and Scope of Genetics. By William Bateson. Cambridge University Press. 1s. 6d. net
Genetics is Professor Bateson's name for the philosophy of heredity and variation, and this study of genetics is the author's inaugural lecture on his appointment to the Darwin Chair of Biology at Cambridge. It forms an excellent introduction to Mendelism, and embraces a vigorous and convincing advocacy of eugenics.

Marriage and Motherhood. By H. S. Davidson. Jack .. .. 6d.
The writer warns the expectant mother, very wisely, against seeking advice from elderly, gossiping women, who are full of a wondrous lore on the mysteries of maternity, which consists chiefly of foolish and sometimes harmful superstitions. To remove the need for going to such contaminated sources for information, Dr. Davidson tells clearly all that is most necessary for a prospective or actual mother to know.

A Study of British Genius. By Havelock Ellis. 314 pages. Hurst and Blackett .. .. 7s. 6d.
The greater part of the book is devoted to the arrangement and collection of all available facts, the Dictionary of National Biography being the source of most of the materials. Concludes that the characteristics of men of genius are probably independent, to a large extent, of the particular field in which their ability is shown. Youngest and eldest children are generally the most gifted.

Memories of My Life. By Francis Galton. Methuen. 10s. 6d.
A model autobiography of the founder of the science of eugenics. The life-story is so closely woven with the phiiosophy of human welfare that it must be studied. The last five chapters bear largely on eugenics, especially the last two, which deal with race improvement.

Wastage of Child Life. By J. Johnston. 95 pages. A. C. Fifield .. .. 6d.
A splendid little book on the awful wastage of life involved in neglected childhood. Dr. Johnston illustrates his case by conditions in Lancashire, which are, of course, exceptional. Much of the book is generally applicable to other parts, and it is a terrible book to read.

Essays in Eugenics. By Sir Francis Galton. Eugenics Education Society .. .. .. 1s. 6d.
A collection of essays issued by the Eugenics Education Society to neutralise misrepresentations of eugenics by writers in the Press who misapprehend its purpose. It contains several lectures and papers by its author that are unobtainable in any other form. The author explains clearly what Eugenists do and what they do not seek to attain.

The Health of the School Child. By W. Leslie Mackenzie. 127 pages. Methuen .. 2s. 6d.
A useful study of what may be done through the medical inspection of school children. The experience of the author has been gained in Scotland, and he is also acquainted with German organisation of school inspection from a medical point of view. A most careful sketch of a most hopeful movement.

Parenthood and Race Culture: an Outline of Eugenics. By C. W. Saleeby. 331 pages. Cassell. 7s. 6d. net
An attempt to survey and define the whole field of the new science of improving the race of human beings. Shows that eugenics is at once a science and a religion, based upon the laws of life, and recognising in them the foundation of society. The author contributes the Eugenics section to "Popular Science."

Public Control of the Liquor Traffic. By Joseph Rowntree and A. Sherwell. 326 pp. Richards. 2s. 6d.
An examination of the public management of the liquor traffic, with special reference to what has been done in this connection in Sweden and Norway. The authors, after a full examination of the subject, favour company management.

Public Health and Housing. By John F. J. Sykes. 216 pages. P. S. King .. .. .. 5s.
This book divides itself into three parts: the ascertained effects upon health of certain conditions of habitation; construction and misconstruction of human dwellings; and usage and misusage. A thoughtful book, the outcome of wide experience on a serious problem.

The Drink Problem in its Medico-Sociological Aspects. Edited by T. N. Kelynack. 300 pages. Methuen .. .. .. 7s. 6d. net
A survey of the main problems of modern life from many points of view. All the writers speak with authority. Many points of interest are raised, and the individual contributors have not hesitated to express their views on matters on which a disagreement of opinion exists; but throughout the volume a truly scientific presentation of the subject is attained.

Infant Mortality. By Sir George Newman. 366 pp. Methuen .. .. .. 7s. 6d. net
Brings the essential facts of this national question down to 1906, when Sir George Newman set the annual loss to Great Britain by the deaths of infants at 120,000 lives. The book shows how a high infant mortality rate almost necessarily denotes a prevalence of conditions which, in the long run, determine racial degeneration. The effects of occupation of women are traced as bearing on the death-rate, the influences of domestic and social conditions are considered, and the feeding and management of babies discussed. Preventive methods are suggested, working through (1) the mother, (2) the child, (3) the environment.

Problems of Boy Life. Edited by J. H. Whitehouse, M.P. 342 pages. P. S. King .. 10s. 6d.
This volume comprises eighteen thoughtful chapters by different observers, each discussing some phase of difficulty in the case of the boy who is trying to fit himself into the great industrial world. That it is high time for the working life of the child and young person to be taken over by the public for supervision and training is made abundantly clear. The volume gains freshness from its varied authorship, each writer being an enthusiast.

The Temperance Problem and Social Reform. By Joseph Rowntree and Arthur Sherwell. 815 pages. Illustrated. Hodder and Stoughton .. 6s.
Shows how the temperance question has a bearing on social reform at many points, and supplies an invaluable fund of information for the student of social amelioration and the politician. There is a notable absence of the spirit that makes out a case at any cost.

Medical Examination of Schools and Scholars. Edited by T. N. Kelynack. 434 pages. King. 10s. 6d.
In this book thirty-six contributors add together their special experience of the work of the doctor in schools. The aim is essentially practical; that is, to provide a complete guide for school medical officers, and to give educationalists an authoritative exposition of the methods by which the best use may be made of the existing machinery. Administration and organisation are discussed, as well as the main theme of school hygiene.

Alcoholism: A Study in Heredity. By G. Archdall Reid. 294 pages. Ballière .. .. 6s. net
Setting out from the theory that acquired characters are not handed on by parents to children, the writer regards the temptation and disorder of alcoholism as a selective force that is working through the human race, and slowly eliminating the less resistant stocks.

Alcoholism: a Chapter in Social Pathology. By W. C. Sullivan, M.D. 214 pages. Nisbet. 3s. 6d. net
Gives in a clear, concise form a summary of the main facts of the drink question, especially in regard to the connection of alcoholism with industrial conditions. Traces a fifth of the suicides of the country to constant intemperance, and three-fifths of the homicidal crime to the same cause. Holds that chronic intoxication is not due to convivial drinking, but to the use of alcohol as a stimulant to muscular work.

The Feeble-Minded. By E. B. Sherlock. 347 pages. Illustrated. Macmillan .. .. 8s. 6d. net.
A guide to study and practice. Deals with the large class of human beings who do not appear to have attained the average mental level. Earlier chapters concerned with psychological and physical traits that are believed to be connected with mental happenings. Traces the causation of feeble-mindedness, discusses the facts of heredity in relation to it, and gives advice in the handling of the feeble-minded.

PRICES OF BOOKS.

It should be remembered that in practically all cases, whether stated or not, the price of shilling and sixpenny books is *net*. "Cheap Editions" indicates that several editions exist.

PLATES IN POPULAR SCIENCE

ERRATA

PAGE

23 Near top of left-hand column, for three million miles, read three hundred million miles.

397 For England, under lower picture, read Britain.

2826 The rainfall of 82·81 inches at Sydney in 1850 is wrongly given for a day, being the record for the whole year.

3057 On plate facing this page, for Stigma, read Stamen.

3405 For Cephalopada, read Cephalopoda; and for Octupuses, read Octopuses.

PAGE

3512 The reference to page 3611 should be to page 3511.

3917 The figures as to vaccination in the Franco-German War, which have often been quoted, appear to be not well founded, and the Editor regrets having quoted them on the authority of a United States official document.

4405 James Bruce, the explorer of Abyssinia, is here called "Sir James" in error.

GENERAL INDEX

This Index embraces illustrations and reading matter, illustrations being indicated by italic figures.

ANIMAL LIFE

The following are the actual headings of the chapters in this group in their consecutive order through the first six volumes of this work. Specific animals are in their proper places in the index.

B

C

D

EUGENICS

The following are the actual headings of the chapters in this group in their consecutive order through the first six volumes of this work. The subjects are also dealt with in their proper places in the index.

HEALTH

The following are the actual headings of the chapters in this group in their consecutive order through the first six volumes of this work. The subjects are also dealt with in their proper places in the index.

I

INDUSTRY

The following are the actual headings of the chapters in this group in their consecutive order through the first six volumes of this work. The subjects are also dealt with in their proper places in the index.

LIFE

The following are the actual headings of the chapters in this group in their consecutive order through the first six volumes of this work. The subjects are also dealt with in their proper places in the index.

N

PLANT LIFE

The following are the actual headings of the chapters in this group in their consecutive order through the first six volumes of this work. The subjects are also dealt with in their proper places in the index.

POWER

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SOCIETY

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UNIVERSE

The following are the actual headings of the chapters in this group in their consecutive order through the first six volumes of this work. The subjects are also dealt with in their proper places in the index.

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